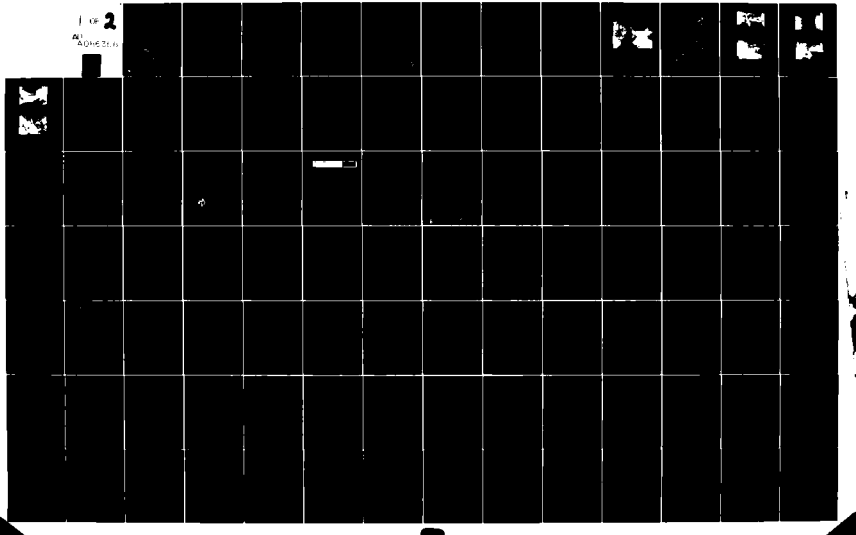
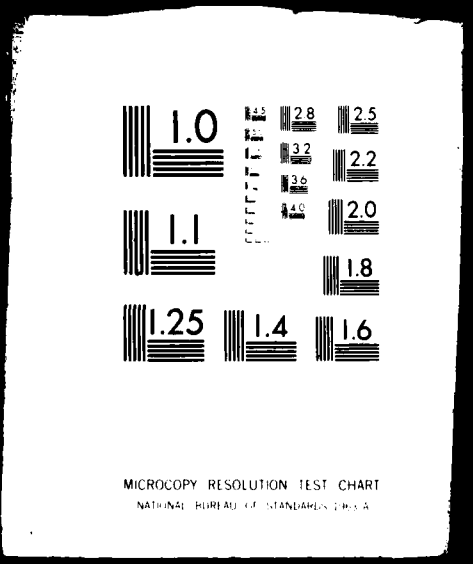
AD-A086 356 NEW YORK STATE DEPT OF ENVIRONMENTAL CONSERVATION ALBANY F/G 13/13
NATIONAL DAM SAFETY PROGRAM. ALPINA DAM (INVENTORY NUMBER NY 77--FTC(U)
FEB 80 J B STETSON DACW51-79-C-0001

UNCLASSIFIED NL

1 OF 2
AD A086356





PHASE I INSPECTION REPORT

LEVEL II

4

ST. LAWRENCE RIVER BASIN

(6) National Dam Safety Program

ACA086356

ALPINA DAM (Inventory Number NY 778)

St. Lawrence River Basin

LEWIS COUNTY
NEW YORK.

~~INVENTORY NO NY 778~~

DTIC
ELECTE
JUL 9 1980
S D
C

PHASE I INSPECTION REPORT,
NATIONAL DAM SAFETY PROGRAM

(10) John B. Cotton

(11) 14 Feb 80

CONTRACT NO. DACW51-79-C0001

(15)

(12) 96

NEW YORK DISTRICT CORPS OF ENGINEERS

(11) JULY 1979

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A086 356 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase 1 Inspection Report Alpina Dam St. Lawrence River Basin, Lewis County, NY Inventory No. NY 778	5. TYPE OF REPORT & PERIOD COVERED Phase I Inspection Report National Dam Safety Program 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John B. Stetson, P.E.	8. CONTRACT OR GRANT NUMBER(s) DACW-51-79-C-0001
9. PERFORMING ORGANIZATION NAME AND ADDRESS Stetson-Dale Engineering Company Bankers Trust Building Utica, NY 13501	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS New York State Department of Environmental Conservation/ 50 Wolf Road Albany, New York 12233	12. REPORT DATE 14 February 1980 13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Department of the Army 26 Federal Plaza/ New York District, CofE New York, New York 10007	15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; Distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety
National Dam Safety Program
Visual Inspection
Hydrology, Structural Stability
Alpina Dam
Lewis County
Diana-Fort Drum

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

The Alpina Dam, an intermediate-sized dam with a low hazard classification, is a water level control structure owned by Niagara Mohawk Power Corporation located within the Military Reservation at Fort Drum. The dam is a concrete gravity weir military structure. The dam is located on the northern end of Mud Lake which is connected to Lake Bonaparte. Numerous summer residences are

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

located on Lake Bonaparte. The downstream area below the dam is a training area on the reservation. No plans exist for the dam, however, field surveys were taken as part of this inspection.

The following actions are recommended:

1. The discharge capacity of the spillway is inadequate for all flows in excess of 5 percent of the PMF (spillway capacity = 412 cfs). The spillway is not considered seriously inadequate based on the Corps of Engineers' screening criteria since the hydrologic/hydraulic analysis indicates that failure of the dam would not pose a high hazard to loss of life from large flows downstream from the dam. However, consideration should be given to provide an emergency spillway adequate to pass 1/2 of the PMF without damage to the structure. This may be accomplished by the construction of an emergency spillway on the undisturbed bank of the impoundment.

2. Operational procedures should be formalized to assure lowering of the impoundment level during the winter months so as to eliminate the possibility of dam failure from ice load at the top of the dam.

3. The wing wall on the west abutment should be repaired. This concrete wall primarily serves as erosion protection of a non-overflow earthen section. Therefore, the repair of this deterioration and undermining is viewed more as a maintenance problem than a structural deficiency at present, however, further deterioration could affect the stability of the dam.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

TABLE OF CONTENTS

FIGURES

APPENDIX

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam Alpina Dam NY778

State Located New York
County Located St. Lawrence
Stream Bonaparte Creek
Date of Inspection May 2, 1979

ASSESSMENT OF GENERAL CONDITIONS

The Alpina Dam, an intermediate-sized dam with a low hazard classification, is a water level control structure owned by Niagara Mohawk Power Corporation located within the Military Reservation at Fort Drum. The dam is a concrete gravity weir military structure. The dam is located on the northern end of Mud Lake which is connected to Lake Bonaparte. Numerous summer residences are located on Lake Bonaparte. The downstream area below the dam is a training area on the reservation. No plans exist for the dam, however, field surveys were taken as part of this inspection.

The following actions are recommended:

1. The discharge capacity of the spillway is inadequate for all flows in excess of 5 percent of the PMF (spillway capacity = 412 cfs). The spillway is not considered seriously inadequate based on the Corps of Engineers' screening criteria since the hydrologic/hydraulic analysis indicates that failure of the dam would not pose a high hazard to loss of life from large flows downstream from the dam. However, consideration should be given to provide an emergency spillway adequate to pass 1/2 of the PMF without damage to the structure. This may be accomplished by the construction of an emergency spillway on the undisturbed bank of the impoundment.

2. Operational procedures should be formalized to assure lowering of the impoundment level during the winter months so as to eliminate the possibility of dam failure from ice load at the top of the dam.

3. The wing wall on the west abutment should be repaired. This concrete wall primarily serves as erosion protection of a non-overflow earthen section. Therefore, the repair of this deterioration and undermining is viewed more as a maintenance problem than a structural deficiency at present, however, further deterioration could affect the stability of the dam.

Dale Engineering Company

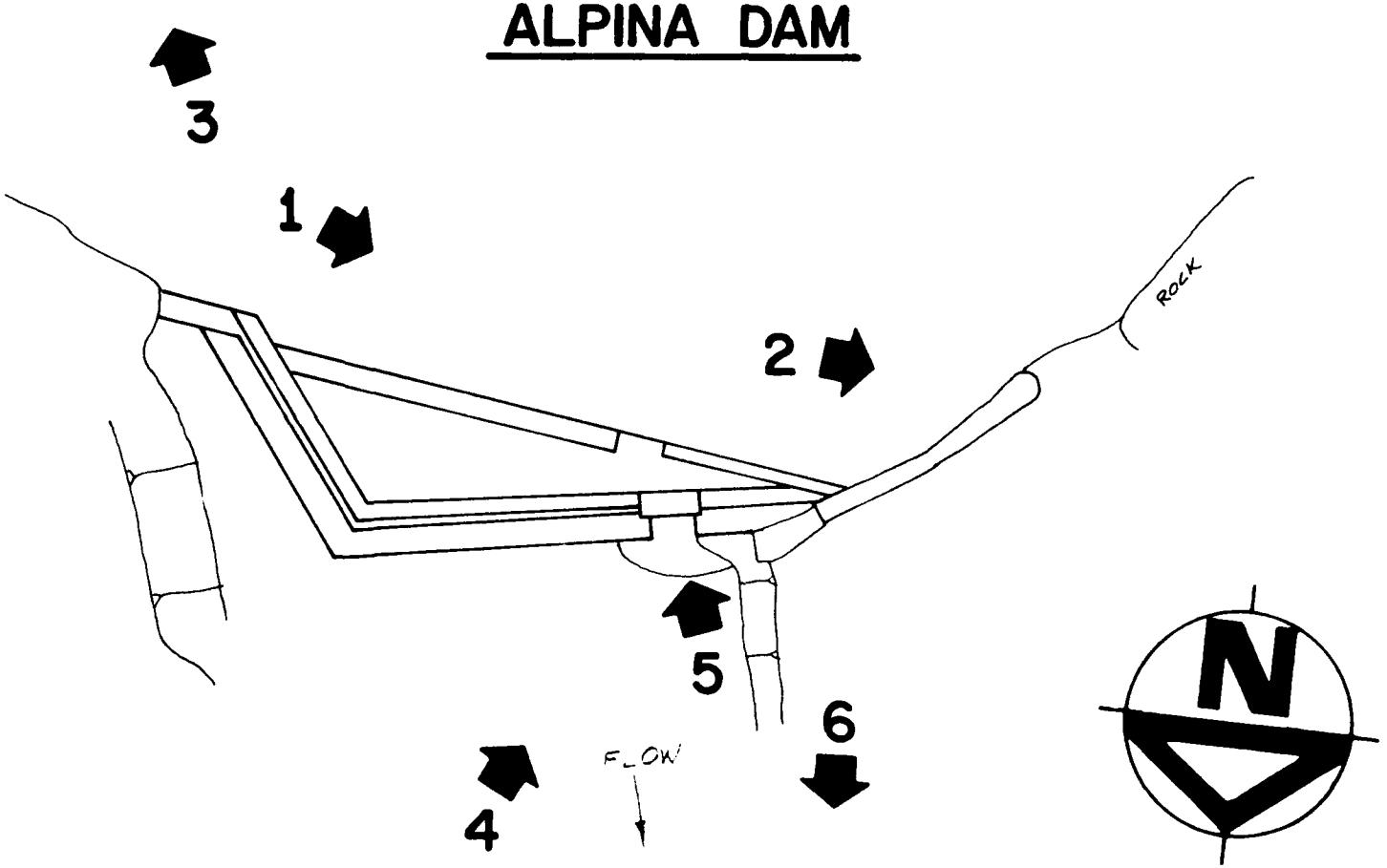
John B. Stetson, President

Approved By: Clark H. Benn
Date: 14 Feb 80

Col. Clark H. Benn
New York District Engineer

Overview of dam spillway system taken from small west earth embankment area.

ALPINA DAM

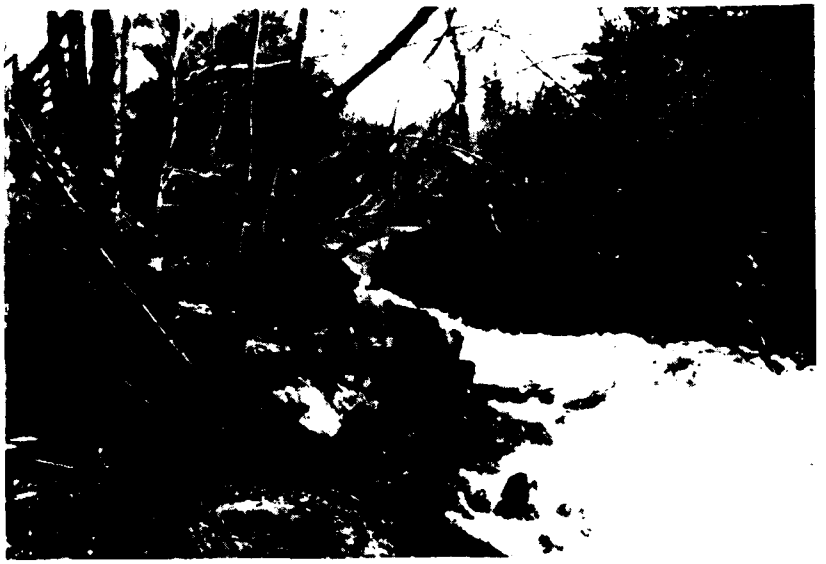


PHOTOGRAPH KEY PLAN

1. Close-up of eastern section of spillway.

2. Notice deterioration of front of wall near west abutment.

3. View of reservoir above dam.



4. Downstream channel looking toward spillway.

5. Close-up of service spillway passage containing stop planks.

6. View downstream from western portion of spillway looking into remains of original dam and spillway section.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM - ALPINA DAM ID# - 778

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

Authority for this report is provided by the National Dam Inspection Act, Public Law 92-367 of 1972. It has been prepared in accordance with a contract for professional services between Dale Engineering Company and Department of the Army, New York District, Corps of Engineers.

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of the Alpina Dam and appurtenant structures, owned by the Niagara Mohawk Power Corporation, and to determine if the dam constitutes a hazard to human life or property and to transmit findings to the New York District, Corps of Engineers.

This Phase I inspection report does not relieve an Owner or Operator of a dam of the legal duties, obligations or liabilities associated with the ownership or operation of the dam. In addition, due to the limited scope of services for these Phase I investigations, the investigators had to rely upon the data furnished to them. Therefore, this investigation is limited to visual inspection, review of data prepared by others, and simplified hydrologic, hydraulic and structural stability evaluations where appropriate. The investigators do not assume responsibility for defects or deficiencies in the dam or in the data provided.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

The Alpina Dam is a concrete gravity dam with bedrock foundations. The overall length of the dam is 120 feet. The maximum height of the dam is 5.6 feet. The spillway of the dam is 63 feet long and forms an angle approximately in the center of the spillway. A small control spillway is located near the west abutment of the dam. This spillway is 5 feet wide and is equipped with stop planks to control the level in the impoundment. The existing dam has been reconstructed just downstream from a structure that is presently submerged in the impoundment. The dam controls the level in Lake Bonaparte and Mud Lake. The receiving channel immediately downstream from the spillway is founded in bedrock and is heavily overgrown with trees and brush. The receiving stream shows no sign of recent erosion.

b. Location

The Alpina Dam is located in the Town of Diana in Lewis County, New York. The dam is also located within the Military Reservation of Fort Drum.

c. Size Classification

The maximum height of the dam is approximately 5.6 feet. It is estimated that the storage capacity is approximately 6,000 acre feet. Therefore, the dam is in the Intermediate Size Classification as defined by The Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification

The receiving stream from the Alpina Dam, Bonaparte Creek flows through the Fort Drum Military Reservation into the Indian River. This river meanders through the flat marshy topography of Fort Drum for approximately 20 miles before it reaches a populated area. Therefore, the dam is in the Low Hazard Classification as defined by The Recommended Guidelines for Safety Inspection of Dams.

e. Ownership

The dam is owned by the Niagara Mohawk Power Company.

f. Purpose of Dam

The main purpose of the dam is to maintain the level in Lake Bonaparte and Mud Lake, and to maintain flows in the receiving stream which flows in the Indian River.

g. Design and Construction History

There is no information available regarding the design or construction of the Alpina Dam. The maps and sketches were prepared from field surveys conducted by Dale Engineering Company. The field investigation indicates that the dam was reconstructed immediately downstream from a similar structure which is visible just below the water surface. The existing structure has a date in the concrete indicating the construction took place in 1933.

h. Normal Operating Procedures

Stop planks in the control sluiceway are removed in the Autumn to draw the lake level down approximately 1 foot during the Winter months. The planks are replaced in the spring to raise the lake level during the Summer recreation season. The location of this facility is remote and seldom visited by the Owner.

1.3 PERTINENT DATA

a. Drainage Area

The drainage area of Alpina (Lake Bonaparte) is 19.65 square miles.

b. Discharge at Dam Site

No discharge records are available for this site.

Computed discharges:

Ungated spillway, top of dam	412 cfs
Ungated spillway, PMF	8923 cfs
1/2 PMF	2327 cfs
Gated drawdown, stop planks	N.C.

c. Elevation Note: There is no U.S.G.S. control in the area. Elevations were determined in local datum and approximate U.S.G.S. elevations are given in parenthesis.

Top of dam	100.05	(769.0)
Maximum pool - PMF		(775.23)
1/2 PMF		(771.14)
Spillway crest	98.5	(767.5)
Stream bed at centerline of dam	92.9	(762.1)

d. Reservoir

Length of normal pool	16500 FT

e. Storage

Top of dam	5970.3±Acre Feet
Normal pool	3257.3±Acre Feet

f. Reservoir Area

Spillway pool	1357.2±Acre

g. Dam

Type - Concrete Gravity.
Length - 120 feet.
Height - 5.6 feet.
Freeboard between normal reservoir and top of dam - 1.5 feet.
Top width - 2 feet.
Side slopes - Downstream 1.6 Vertical, 1 Horizontal
Upstream Vertical

h. Spillway

Type - Broad crested weir.
Length - 63 feet.
Crest Elevation - 98.5 (767.5).
Gates - None.
U/S Channel - Impoundment.
D/S Channel - Bedrock.

i. Regulating Outlets

5 foot long stop plank weir.
Bottom Elevation 94.4 (763.4).
Stop Plank Elevation 95.83 (764.83) (At Time of Inspection).

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

There is no information available regarding the design of the Alpina Lake Dam.

2.2 CONSTRUCTION

No information is available regarding the construction of the dam except that the new structure was built in 1933.

2.3 OPERATION

See Section 4.

2.4 EVALUATION

The Low Hazard Classification of this facility and the present condition of the dam indicates that additional research for data on the structure is not required in order to complete this Phase I Investigation.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

The Alpina Dam was inspected on May 2, 1979. The dam presently functions to maintain water elevations in Lake Bonaparte and Mud Lake for recreational purposes and to augment flow into the Indian River. The Inspection Crew was accompanied on the inspection by Robert Levett and Robert Best of Niagara Mohawk Power Corporation. The Niagara Mohawk Power Corporation is the Owner and operator of this facility.

b. Dam

The dam and spillway system are shown in the Sketches prepared by Dale Engineering Company in Figures 2 and 3. The dam was reconstructed in 1933. The east abutment is along the alignment of the original dam. This abutment is founded on bedrock and there is no indication of seepage along the abutment or along the spillway of the dam. Near the west abutment of the dam, a small walkway crosses the control spillway. The concrete supporting this walkway is cracked near the elevation of the top of the emergency spillway. The west abutment of the dam is also founded on bedrock and meets the alignment of the old dam at the west abutment. On the west abutment, a wing wall which extends beyond the dam structure is deteriorated on the upstream side and severely undermined. The dam is in generally good structural condition except for this wing wall on the west abutment. There is no evidence of cracking nor is there evidence of seepage. There are provisions on the top of the emergency spillway for mounting flashboards, although there are no flashboards in the area of the dam.

c. Spillway

The control spillway was operating at a head of approximately 2.6 feet at the time of the inspection. The surfaces of the spillway were in generally good condition except for the support of the walkway. This spillway discharged into a bedrock channel.

d. Appurtenant Structures

There are no structures appurtenant to this dam. No provisions are made for draining of the dam except for the removal of stop planks in the control spillway.

e. Reservoir Area

The reservoir area is generally forested and does not contribute significant amounts of sediment into the impoundment. There are no areas where bank instability exists around the impoundment.

f. Downstream Channel

The area downstream from the dam is a rock channel in good condition.

3.2 EVALUATION

The Alpina Dam is generally in good condition. The visual inspection disclosed no critical structural defects and no seepage was discovered at the site. The wing wall on the west abutment is however, severely undermined and could collapse.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The operation of the stop planks in the control spillway was not observed by the Inspection Team. Niagara Mohawk Power Corporation removes stop planks in the Fall to drop the water level in Lake Bonaparte and Mud Lake during the Winter months. The stop planks are replaced in the Spring to restore the recreation pool in the impoundment.

4.2 MAINTENANCE OF THE DAM

The dam is in a remote area that is inaccessible during the Summer months due to military activities in the area.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 DRAINAGE BASIN CHARACTERISTICS

The Alpina Dam is located on Bonaparte Creek and contains Mud Lake and Bonaparte Lake. The drainage area of the dam is 19.65 square miles. The topography consists of mildly sloped terrain in a highly forested area. The surface area of Lake Bonaparte in 1280 acres.

5.2 ANALYSIS CRITERIA

The purpose of this investigation is to evaluate the dam and spillway with respect to their flood control potential and adequacy. This has been assessed through the evaluation of the Probable Maximum Flood (PMF) for the watershed and the subsequent routing of the flood through the reservoir and the dam's spillway system. The PMF event is that hypothetical flow induced by the most critical combination of precipitation, minimum infiltration loss and concentration runoff of a specific location that is considered reasonably possible for a particular drainage area. Since this dam is in the Small Dam Category and is a High Hazard, the guidelines criteria (Ref. 1) require that the dam be capable of passing one-half the Probable Maximum Flood.

The hydrologic analysis was performed using the unit hydrograph method to develop the flood hydrograph. Due to the limited scope of this Phase I investigation, certain assumptions, based on experience were used in this analysis and in the determination of the dam's spillway capacity to pass the PMF. In the event that the dam could not pass the 1/2 Probable Maximum Flood without overtopping, an additional analysis are to be performed on potential dam failure if the dam designated as a High Hazard Classification. This process was done with the concept, that if the dam was unable to satisfy this criteria, further refined hydrologic investigations would be required.

Since the Alpina Dam is a Low Hazard Classification and not a High Hazard Classification, hydrologic dam break analysis has not been provided or started above according to the screening criteria.

The U.S. Army Corps of Engineers, Hydrologic Engineering Center's Computer Program HEC-1 DB using the Modified Puls Method of flood routing was used to evaluate the dam, spillway capacity, and downstream hazard.

The unit hydrographs were defined by Snyder Coefficients, Tp and Cp. The coefficient Ct was set at 2.0, while Cp was set at 0.625. The Probable Maximum Precipitation (PMP) was 18.5 inches, Hydrometeorological Report (HMR #33) for a 24 hour duration, 200 square mile basin. Base flow for the basin was assumed to be 2 cubic feet per second per square mile, while loss rates were set at 1.0 inch initial abstraction and 0.1 inches/hour continuous loss rate. The loss rate function yielded 82 percent runoff from the PMF. The PMF inflow

hydrograph was determined by applying the PMP to the unit hydrographs and runoff and routing to the dam sites (Figure 5). The PMF results in an inflow into the impoundment of 26,219 cfs. The 1/2 PMF inflow is 13,116. Due to the storage effect of the lake, the discharges were significantly reduced to 8,923 cfs for the Probable Maximum Flood and 2,377 for the 1/2 PMF.

5.3 SPILLWAY CAPACITY

The spillway is a weir type structure 70 feet in length. A spillway coefficient of 3.2 was assigned for the spillway rating curve development. The spillway crest in only 1.5 feet below the top of dam and therefore only has 412 cfs discharge capacity.

	Discharge	Spillway Capacity	Depth Over Dam
PMF	8,923	5%	6.23 ft.
1/2 PMF	2,377	17%	2.14 ft.

5.4 RESERVOIR CAPACITY

The reservoir storage capacity is given below. This was estimated for USGS mapping.

Top of Dam	5,125 Acre Feet
Crest of Spillway	3,116 Acre Feet

5.5 FLOODS OF RECORD

There is no information on water levels at the dam site.

5.6 OVERTOPPING POTENTIAL

The HEC1-DB analysis indicates that the dam will be overtopped as follows:

OVERTOPPING IN FEET

PMF	6.23
1/2 PMF	2.14

The downstream hazard is a lightly traveled road south of the creek about 4 miles below the dam. Should dam failure occur, this road would be overtopped in the order of the dam overtopping.

5.7 EVALUATION

The limited spillway capacity will result in overtopping of the dam for less than a 1/2 Probable Maximum event. Therefore, the spillway is an inadequate spillway system on a Low Hazard Classification dam (for all flows beyond 17% of the Probable Maximum Flood).

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

The concrete dam retains stability with no indication of misalignment, settlement or other structural movement. Generally, the physical condition of the visible dam sections are good to fair, but a wing wall section at the westerly abutment is deteriorating along with its stone foundation. No indication of seepage was evident in the vicinity of this abutment. Minor seepage through/under the concrete structure was noted at two isolated locations, on the main dam section and the emergency spillway adjacent to the easterly abutment.

Rock outcrops surround the vicinity of the dam location. The dam abutments terminate in rock and bedrock lies exposed in the immediate spillway areas. Observations of the visible areas of dam base indicated this structure is founded directly on rock.

b. Geology and Seismic Stability

The Alpina Dam area is located within the western edge of the foothills of the Adirondack Province. It is also within Watershed No. 386 of the St. Lawrence River Basin according to the U.S. Department of Agriculture 1970 River Basin Study.

Bedrock at the dam site is a biotite-quartz-plagioclase gneiss. In places it is garnetiferous. The foliation of the gneiss strikes northeast and dips steeply to the northwest. Jointing is common with the approximately east-west joint set being the dominant set. Although gneiss is generally known to have considerable strength and bearing capacity weathering of the biotite and plagioclase components of the rock may yield rotted seams conducive to seepage.

There are no known faults or shear zones in the vicinity of the dam according to the N.Y.S. Geologic Map (1970) and the Preliminary Brittle Structures Map of the New York State Geologic Survey (1977). About four miles north of the dam is a shear zone (fault) trending northeast according to the New York State Geologic Map (1970). An extensive northeast trending shear zone, about three miles wide, is located approximately four miles to the southeast of the dam according to the Brittle Structures Map. This map also shows several northeast trending linear features, the closest being about 3/4 miles northwest of the dam.

Although the area is apparently located in Zone 2 of the Seismic Probability Map, no earthquakes have been recorded in the immediate area. Approximately 27 miles to the southwest, in the Watertown area, five minor earthquakes were recorded between 1932 and 1963;

none greater than III (Modified Mercalli Scale). An earthquake of intensity VI had been recorded near Lowville approximately 32 miles to the south.

c. Data Review and Stability Evaluation

No information relating to the design and construction of the dam structure has been made available. A field survey undertaken as part of this Phase I study has provided information on dam cross-sections (Figures 2 & 3) but did not extend to determining properties of the dam's concrete and foundation rock. Stability evaluations have been performed, utilizing the obtained cross-section information to obtain an indication of the dam's performance when subject to different possible loading conditions. In these analyses, assumptions were required in regard to concrete and rock properties, the geometry of the dam, and cross-section for the assumed critical location.

The affects of a reservoir at spillway level along with ice affects and a reservoir at the PMF level have been studied. The results for these different conditions are summarized in the following table. The analyses are included in Appendix D.

RESULTS OF STABILITY COMPUTATIONS

Loading Condition	Factor of Safety* Overturning	Sliding
(I) Reservoir level at spillway elevation,		
(i) no uplift on base, no ice	25+	---
(ii) uplift on base, no ice	3.7+	---
(iii) uplift on base, ice one foot thick	0.55+	8.5+
(iv) no uplift on base, ice one foot thick	0.64+	---
(II) Reservoir level at PMF elevation,		
(i) no uplift on base, no tailwater depth	1.65+	---
(ii) uplift on base, no tailwater depth	0.75+	18+

*These factors of safety indicate the ratio of moments resisting overturning to moments causing, and the ratio of forces resisting sliding to those causing; a ratio less than unity represents instability. The analysis considered the level of the downstream pool to be at the base of the dam section.

The analysis indicates unsatisfactory stability against overturning for certain combinations of loading conditions.

Somewhat surprising is the instability indicated for a normal reservoir elevation with ice acting, a condition presumed to have occurred in the past without effecting damage. The practice of lowering the reservoir level in winter may have resulted in ice pressures being resisted by the abandoned submerged dam section immediately behind the newer structure. The narrow shape and relatively small size of the impounding area immediately behind the dam may also influence and limit the extent of ice forces being imposed against the dam structure, the expansive pressures due to daily temperature variations being accommodated by encroaching upward on the reservoir's sidebanks. Limited tensile strength from the bond between dam concrete and rock formation also could be acting to assist stability.

Also critical to the stability is the presence of uplift water pressures acting on the base of the dam for some loading combinations. The analysis uplift force was based on full headwater hydrostatic pressure acting on the dam's upstream corner of the base and a zero tailwater pressure on the dam's downstream corner. The resulting triangular pressure pattern is considered to act on 100 percent of the dam base area. The assigned uplift force represents a conservative design practice utilized where actual conditions are not known. The assumed condition could be too severe if the dam is embedded in sound rock. If the rock is very sound and impermeable, seepage would be very low and uplift pressures of significance would require a long period of time to develop. A conclusion for such a condition is that the computed uplift may not exist at the present time and only develop at a future time. Site conditions imply the existance of sound foundation rock with no observation indicating seepage pressures at the downstream toe of the dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

On the basis of the Phase I visual examination and analysis, it has been concluded that the dam's spillway has been found to be inadequate. The hydrologic analysis indicates that the spillway will not pass the 1/2 Probable Maximum Flood without overtopping the dam. The spillway capacity is 412 cfs without flashboards. This spillway capacity relates to 5 percent of the Probable Maximum Flood.

The dam should be further checked to determine if it is in compliance with State regulations.

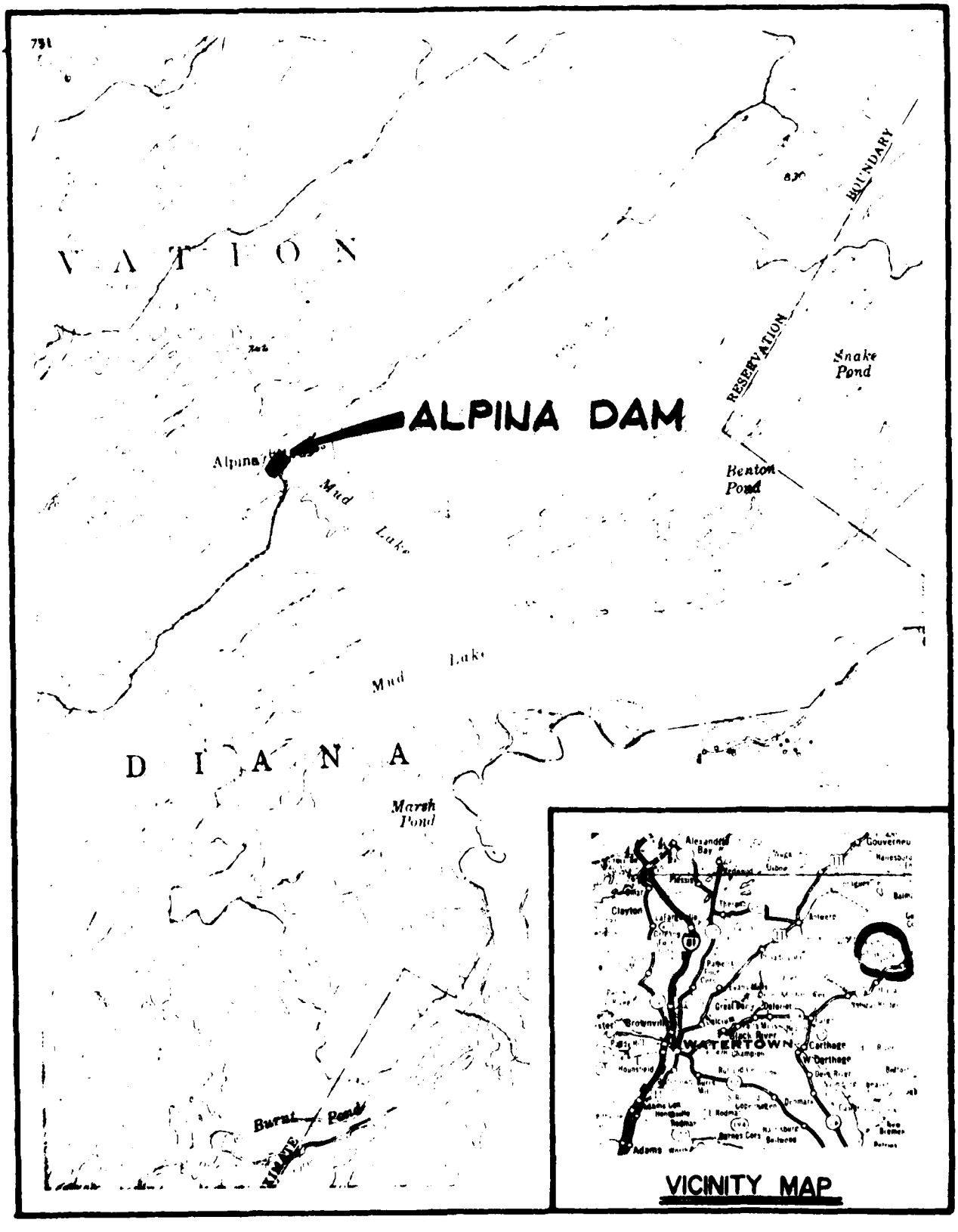
Additionally, the deteriorated condition of the wing wa'l on the west abutment is an area of concern and needs attention. This undermined wing wall could conceivably collapse with continued ice pressures during the severe northern winters. The stability analysis performed indicates that the factor of safety against overturning with a horizontal ice force acting at the top of the dam is 0.64, even when no uplift pressure beneath the dam is considered. Therefore, winter lowering of the dam should be continued in the future, otherwise the dam would require strengthening.

7.2 REMEDIAL MEASURES

a. The discharge capacity of the spillway is inadequate for all flows in excess of 5 percent of the PMF (spillway capacity = 412 cfs). The spillway is not considered seriously inadequate based on the Corps of Engineers' screening criteria since the hydrologic/hydraulic analysis indicates that failure of the dam would not pose a high hazard to loss of life from large flows downstream from the dam. However, consideration should be given to provide an emergency spillway adequate to pass 1/2 of the PMF without damage to the structure. This may be accomplished by the construction of an emergency spillway on the undisturbed bank of the impoundment.

b. Operational procedures should be formalized to assure lowering of the impoundment level during the winter months so as to eliminate the possibility of dam failure from ice load at the top of the dam.

c. The wing wall on the west abutment should be repaired.



LOCATION PLAN

FIGURE 1

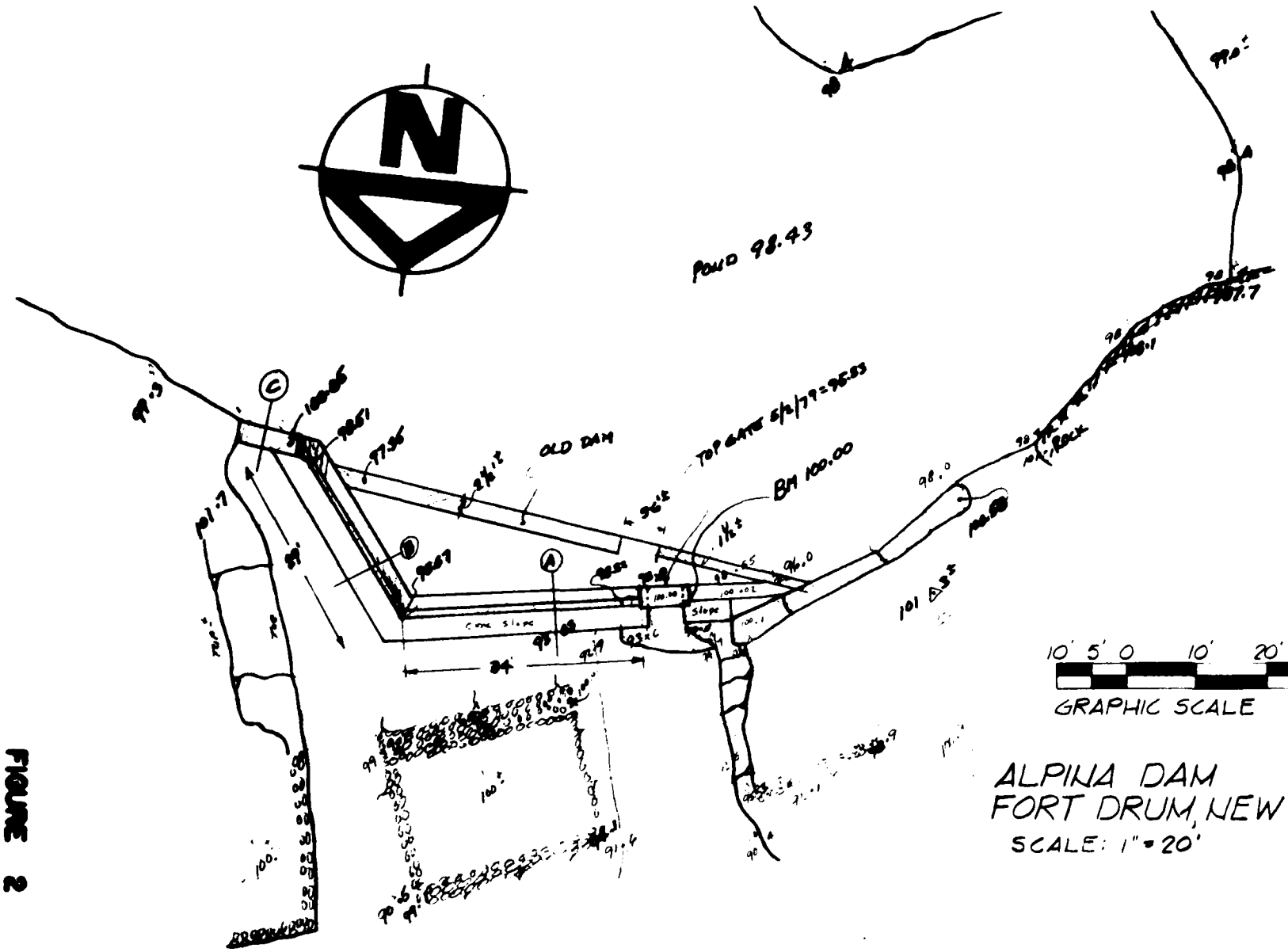
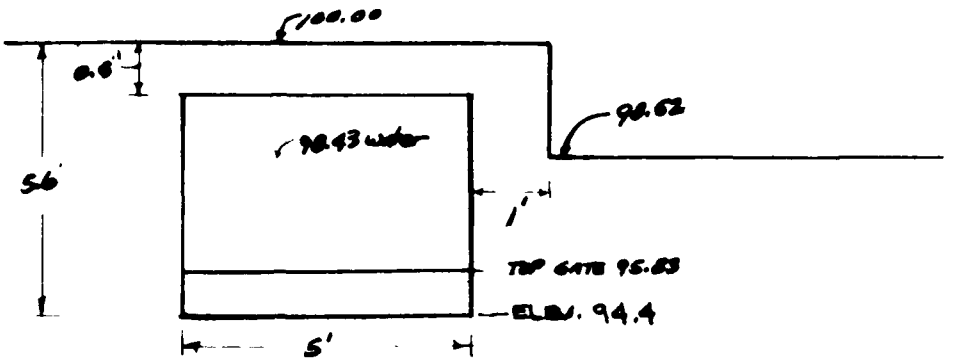
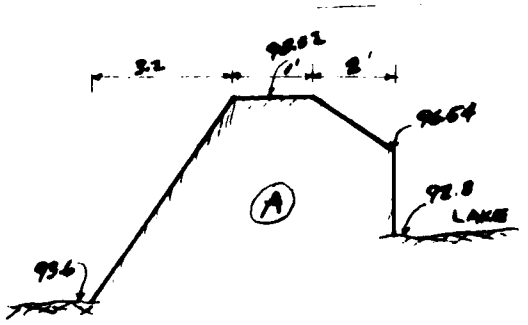


FIGURE 2

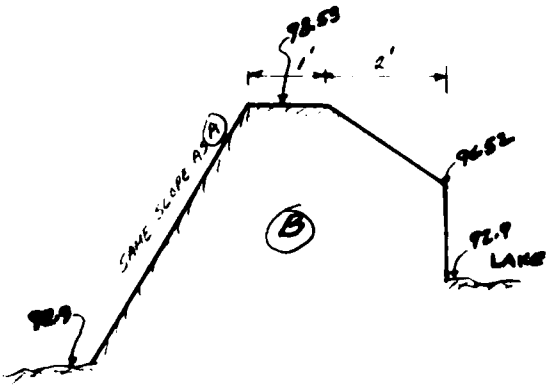
ALPINA DAM
FORT DRUM, NEW YORK
SCALE: 1" = 20'



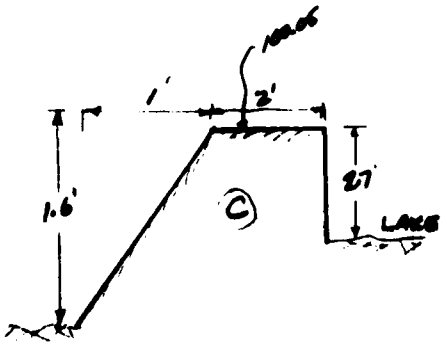
OUTLET ELEVATION



DAM SECTION



DAM SECTION



DAM SECTION

ALPINA DAM
FORT DRUM, NEW YORK
NO SCALE

FIGURE 3

EDUCATIONAL LEAFLET

NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF EDUCATIONAL SERVICES

This material is reprinted from the Department's official magazine–
THE CONSERVATIONIST

LAKE BONAPARTE

1. Although the early fish collection sheets list the lake whitefish, *Coregonus clupeaformis*, as being present, only the cisco (or lake herring), *Coregonus artedii*, is currently known. One might speculate that *artedii* was introduced during the long past whitefish stocking program, if Bonaparte was on that stocking list.
   No lake trout reported caught since 1925.
   1974 began a three-year experimental stocking of brown trout - 1,000 BT Yearlings/year.
   Another species may be required for the deep water in the western end.

LOCATION:
North central Lewis County.

HISTORICAL:
Named after Joseph Bonaparte (brother of Napoleon I) who acquired extensive lands around lake in 1825.

PHYSICAL FEATURES:

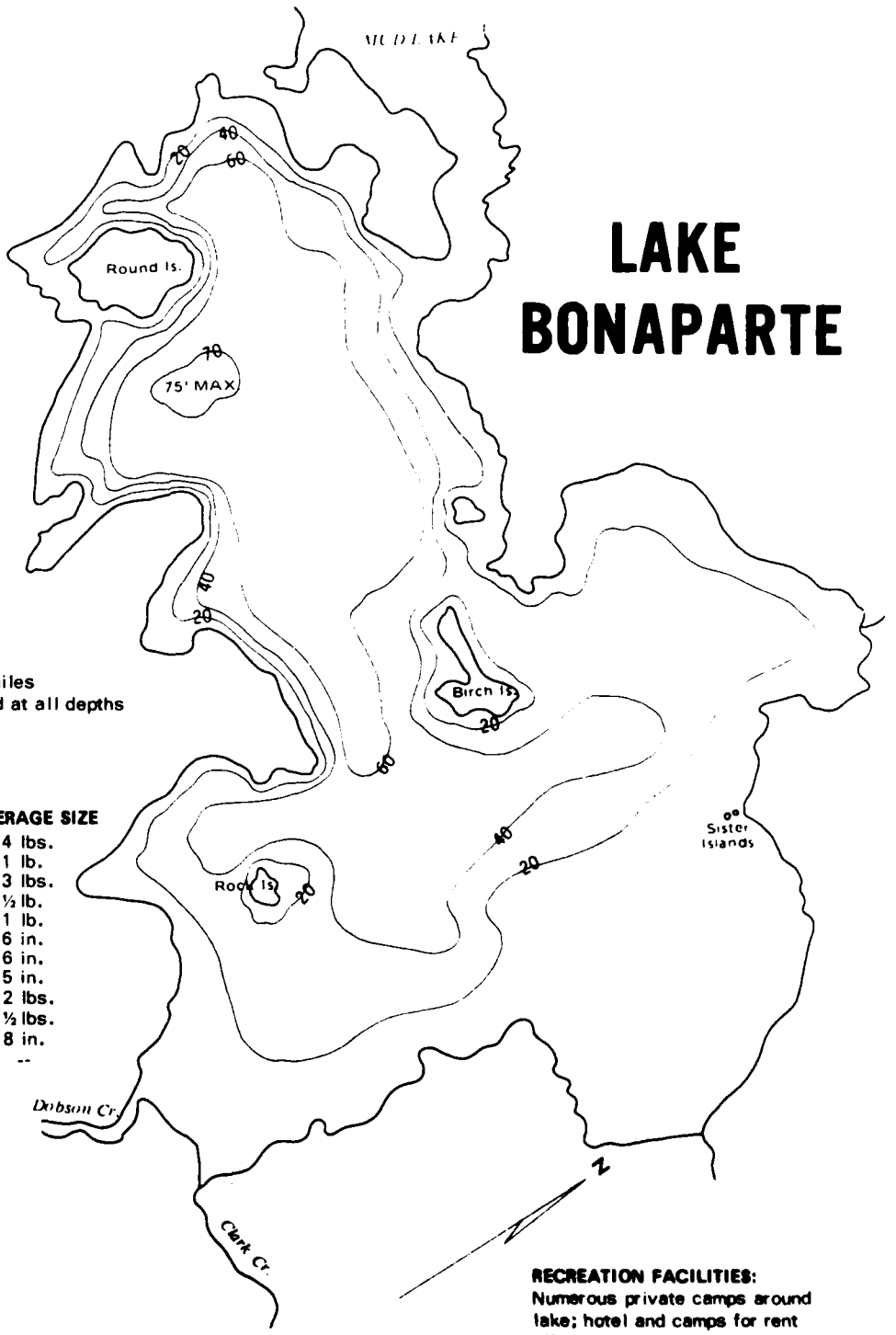
Area: 1,280 acres	Length: 2.4 miles
Elevation: 768 feet	Oxygen: Good at all depths
Maximum Depth: 75 feet	Water: Hard
Maximum Width: 1.5 miles	pH: Alkaline

FISHING:

SPECIES	ABUNDANCE	AVERAGE SIZE
Walleyes	Common	4 lbs.
Smallmouth Bass	Common	1 lb.
Northern Pike	Common	3 lbs.
Cisco	Common	½ lb.
Brown Bullhead	Abundant	1 lb.
Rock Bass	Abundant	6 in.
Yellow Perch	Abundant	6 in.
Pumpkinseed	Abundant	5 in.
Burbot	Common	2 lbs.
Largemouth Bass	Common	1½ lbs.
Black Crappie	Rare	8 in.
Golden Shiner	Common	--

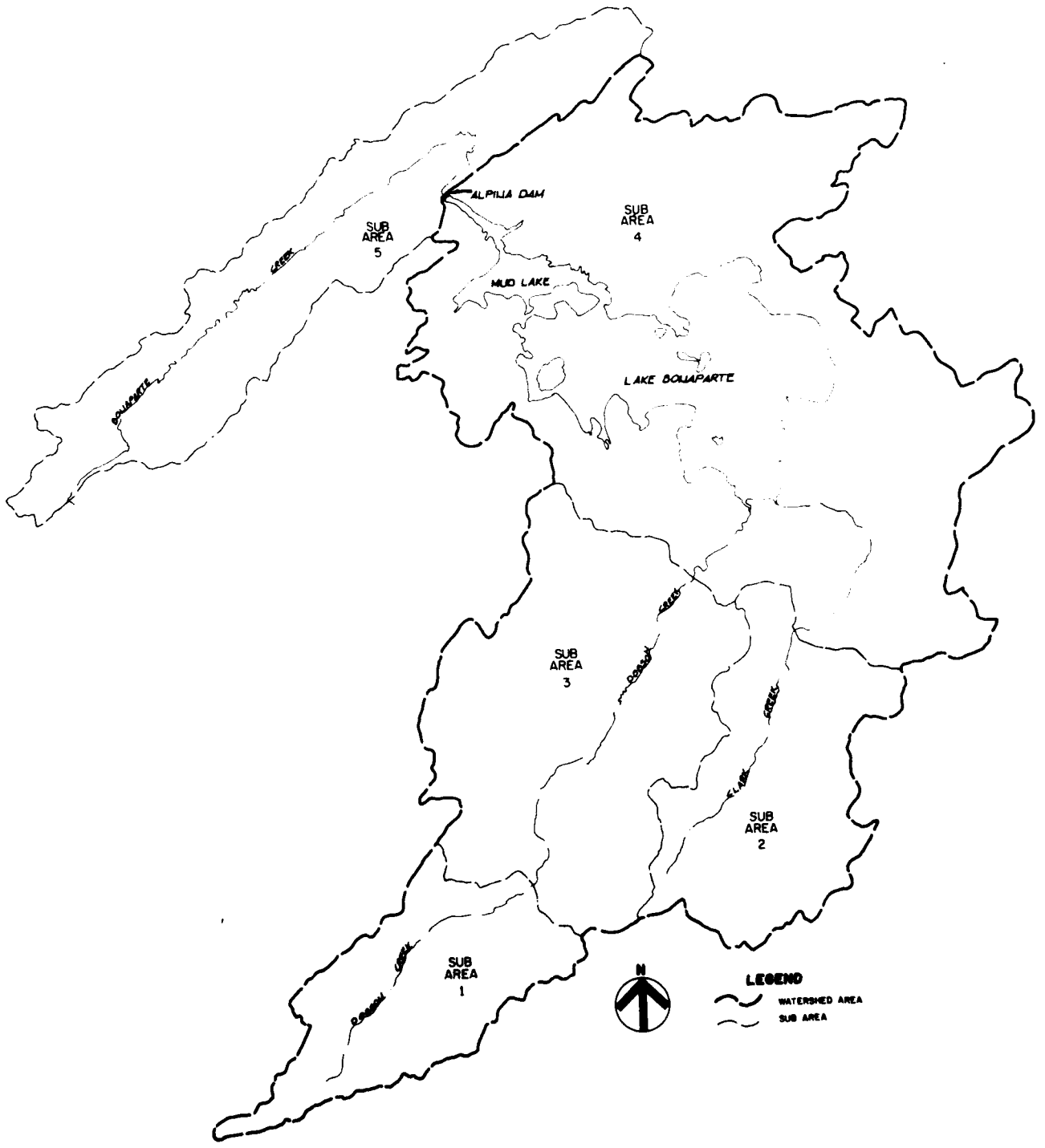
Walleyes: Trolling June bug spinner, worms food all season; some still fishing; deep water along edges, weed beds, rocky shoals best.
Smallmouth Bass: Plugging along rocky shorelines good.
Pike: Plugging, trolling around weedy areas good.
Bullheads: Good spring or fall with worms.

STOCKING:
Walleye fry annually



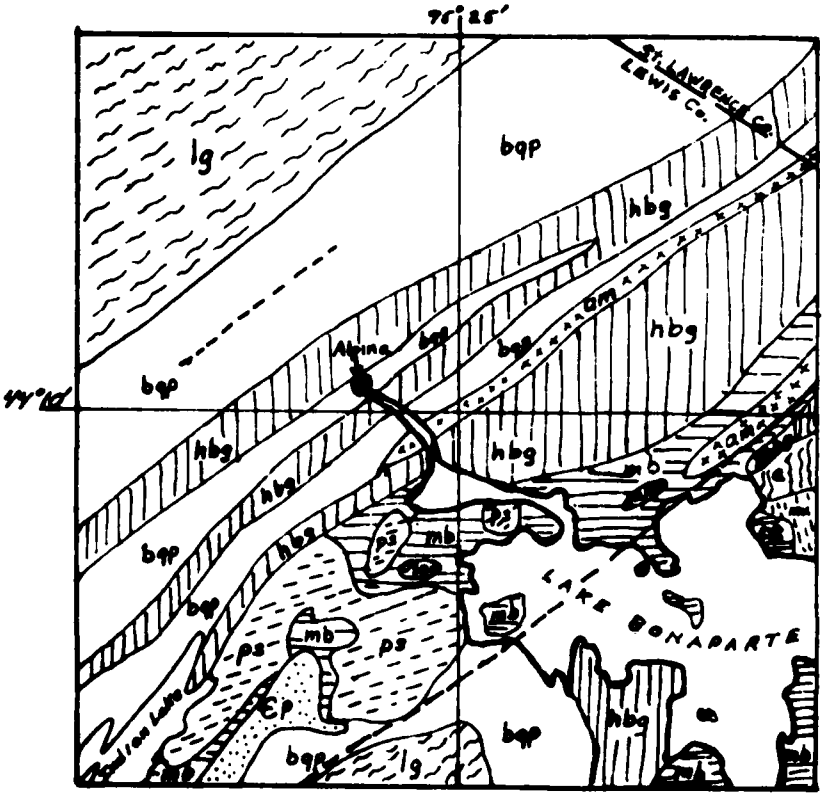
RECREATION FACILITIES:
Numerous private camps around lake; hotel and camps for rent offer accommodations for visitors; boats and bait available; good swimming in sand bays.

FIGURE CON-218



DRAINAGE BASIN PLAN

FIGURE 5



LEGEND

CAMBRIAN

Ep - Potsdam Sandstone

PRECAMBRIAN

bqp - Biotite-quartz-plagioclase gneiss

hbg - Biotite-hornblende-granitic gneiss

lg - Leucogranitic (alaskitic) gneiss

am - amphibolite

mb - marble

cs - marble

ps - syenitic gneiss

mu - metasedimentary rock

a - anorthositic gneiss

Lineament from N.Y.S. Preliminary Brittle Structure Map (1977)

GEOLOGIC MAP

FIGURE 6

APPENDIX A

FIELD INSPECTION REPORT

CHECK LIST
VISUAL INSPECTION

PHASE 1

Name Dam Alpina County Lewis State New York ID # _____

Type of Dam Concrete Hazard Category Low

Date(s) Inspection May 2, 1979 Weather Sunny Temperature 65-70

Pool Elevation at Time of Inspection 767.50 M.S.L. Tailwater at Time of Inspection ----

Inspection Personnel:

F.w. Byszewski	Stetson-Dale	
F.D. McCarthy	Stetson-Dale	
N.F. Dunlevy	Stetson-Dale	
Robert Levett	Niagara-Mohawk	
Robert Best	Niagara-Mohawk	

N.F. Dunlevy Recorder

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	No seepage.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	None.	
DRAINS	None.	
WATER PASSAGES	None.	
FOUNDATION	No data.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	None.	
STRUCTURAL CRACKING	Crack in spillway east portion.	
VERTICAL & HORIZONTAL ALIGNMENT	Good.	
MONOLITH JOINTS		
CONSTRUCTION JOINTS		
STAFF GAGE OF RECORDER		

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None.	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Good.	
RIPRAP FAILURES	None. No riprap.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No problems.	
ANY NOTICEABLE SEEPAGE	None.	
STAFF GAGE AND RECORDER		
DRAINS		

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Good condition.	
APPROACH CHANNEL	Head of dam.	
DISCHARGE CHANNEL	Well graded slope on rocks.	
BRIDGE AND PIERS	None.	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	None.	
APPROACH CHANNEL	None.	
DISCHARGE CHANNEL	None.	
BRIDGE AND PIERS	None.	
GATES AND OPERATION EQUIPMENT	None.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	None.	
INTAKE STRUCTURE	Sluice gate - stop logs 2 x 10's	
OUTLET STRUCTURE		
OUTLET CHANNEL	Clear, well graded on rock.	
EMERGENCY GATE		

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Some fallen tree debris, not a problem.	
SLOPES	Well graded.	
APPROXIMATE NO. OF HOMES AND POPULATION	None on Military Reservation.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Flat slopes.	
SEDIMENTATION	None. Water clear. Rock bottom visible.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE 1

NAME OF DAM _____

ID # _____

ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	See this report.
CONSTRUCTION HISTORY	New dam built - 1933.
TYPICAL SECTIONS OF DAM	None. Surveys taken by inspection team.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	See information provided in this report.
RAINFALL/RESERVOIR RECORDS	None.

ITEM	REMARKS
DESIGN REPORTS	None.
GEOLOGY REPORTS	None.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	No data.
POST-CONSTRUCTION SURVEYS OF DAM	See this report.
BORROW SOURCES	No data.

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	No data.
HIGH POOL RECORDS	No data.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	No data.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	No data.
MAINTENANCE OPERATION: RECORDS	Sluice will take 10 - 2 x 10 stop logs Fall down 1 foot for winter. Allowed to go up 6 inches.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	See survey data.
OPERATING EQUIPMENT PLANS & DETAILS	None.

CHECK LIST
HYDROLOGIC & HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 19.65

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 768

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): ----

ELEVATION MAXIMUM DESIGN POOL: ----

ELEVATION TOP DAM: 769

CREST:

a. Elevation 767.5
b. Type Concrete Weir
c. Width 3.0
d. Length 63.0
e. Location Spillover Center dam
f. Number and Type of Gates

OUTLET WORKS:

a. Type Stop planks
b. Location Center dam
c. Entrance Inverts 763.4
d. Exit Inverts 763.4
e. Emergency Draindown Facilities ----

HYDROMETEOROLOGICAL GATES:

a. Type ----
b. Location ----
c. Records ----

MAXIMUM NON-DAMAGING DISCHARGE: ----

APPENDIX B

PREVIOUS INSPECTION REPORTS/RELEVANT CORRESPONDENCE

APPENDIX C

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

STETSON • DALE BANKERS TRUST BUILDING UTICA • NEW YORK • 13501 TEL 315-797-5800

DESIGN BRIEF

PROJECT NAME NEW YORK STATE DAM INSPECTION DATE 5.3.79

SUBJECT ALPINA DAM (FORT DRUM, NY) PROJECT NO 2277

ESTIMATE OF CLARK'S PARAMETERS DRAWN BY JPG

ESTIMATE OF T_c

ASSUME . $\bar{K}/(T_c+R)$
$R = T_c$ *

$T_c = 11.9\ (L^3/H)^{.385}$

	L(mi)	H(FT)	T_c & R
SUB AREA 1	2.936	95	7.15
" " 2	2.273	200	3.99
" " 3	2.652	130	5.63
" " 4	3.788	182	7.47
" " 5	4.356	155	9.34

SCS

CALCULATION OF CN

AREA 2 = 9 x 72 = 648
91 x 66 = 6006
6654 ÷ 100 = 67

AREA 3 = 9 x 72 = 648
91 x 66 = 6006
6654 ÷ 100 = 67

AREA 4 = 38 x 72 = 2736
62 x 66 = 4092
6828 ÷ 100 = 69

$L = \dfrac{l^{.8}\ (S+1)^{.7}}{1900\ Y^{.5}}$ $\quad S = \dfrac{1000}{CN} - 10$ $\quad T_c = L/.6$

	l(FT)	S	Y(%)	L (Hrs)	T_c & R (Hrs)
SUB AREA 1	15500	3.89	5	1.609	2.68
" " 2	12000	4.92	5	1.499	2.49
" " 3	14000	4.92	5	1.695	2.83
" " 4	20000	4.49	5	2.140	3.57
" " 5	23000	3.89	5	2.206	3.68

STETSON • DALE BANKERS TRUST BUILDING UTICA • NEW YORK • 13501 TEL 315-797-5800

DESIGN BRIEF

PROJECT NAME NEW YORK STATE DAM INSPECTION DATE 5-3-79

SUBJECT ALPINA DAM (FORT DRUM, NY) PROJECT NO 2277

ESTIMATE OF SNYDER'S PARAMETERS DRAWN BY JPG

640 C_p = 400

		C_p
SUB AREA	1	.625
" "	2	.625
" "	3	.625
" "	4	.625
" "	5	.625

$t_p = C_t (L \cdot L_{ca})^{.3}$

		C_t	L	L_{ca}	t_p
SUB AREA	1	2.0	2.936	1.000	2.763
" "	2	2.0	2.273	1.100	2.633
" "	3	2.0	2.652	1.325	2.916
" "	4	2.0	3.788	2.415	3.885
" "	5	2.0	4.356	2.604	4.144

$t_r = t_p / 5.5$

		t_p	t_r
SUB AREA	1	2.763	.502
" "	2	2.633	.479
" "	3	2.916	.530
" "	4	3.885	.706
" "	5	4.144	.753

$t_{pr} = t_p + .25 (t_R - t_r)$

		t_p	t_R	t_r	t_{pr}
SUB AREA	1	2.763	1.0	.502	2.88
" "	2	2.633	1.0	.479	2.76
" "	3	2.916	1.0	.530	3.03
" "	4	3.885	1.0	.706	3.96
" "	5	4.144	1.0	.753	4.21

STETSON • DALE BANKERS TRUST BUILDING UTICA • NEW YORK • 13501
TEL 315-797-5800

DESIGN BRIEF

PROJECT NAME New York State Dam Inspection DATE 5.3.79

SUBJECT Alpina Dam (Fort Drum, NY) PROJECT NO 2277

Depth - Duration Relationship DRAWN BY JPG

Hydrometeorological Report № 33

PMP Index Rainfall

200 Sq Mi
24 Hr - 18.5"

Duration	%	Depth
6 Hr	98	18.13
12 Hr	116	21.46
24 Hr	126	23.31
48 Hr	146	27.01

STETSON • DALE BANKERS TRUST BUILDING UTICA • NEW YORK • 13501
TEL 315-797-5800

DESIGN BRIEF

PROJECT NAME NEW YORK STATE DAM INSPECTION DATE 5-18-79

SUBJECT DAM BREAK ANALYSIS PROJECT NO 2277

ALPINA DAM DRAWN BY JRG

DOWNSTREAM CONTROL POINT - CONFLUENCE OF BONAPARTE CREEK W/INDIAN RIVER (ELEV - 685.0±)

	1/2 PMF		PMF	
	STAGE (EL)	DEPTH (FT)	STAGE (EL)	DEPTH (FT)
WITHOUT DAM FAILURE	687.0	2.0	689.5	4.5
WITH DAM FAILURE				
PLAN 1 EMBANKMENT WASHOUT 2 HR DURATION	689.5	4.5	691.2	6.2
PLAN 2 EMBANKMENT WASHOUT 4 HR DURATION	689.6	4.6	691.3	6.3
PLAN 3 EMBANKMENT WASHOUT 6 HR DURATION	689.6	4.6	691.5	6.5

```
1A1   ALPINA (LAKE BONAPARTE)
 A2  HEC-1DB
 A3  PMF-DAM OVERTOPPING ANALYSIS
 B     90       1       0       0       0       0       0       0       4
 B1     5
 J      1       6       1
 J1    .2      .4      .5      .6      .8     1.0
 K      0       1       0       0       0       0       1
 K1 SUB AREA 1 RUNOFF - SNYDER'S METHOD
 M      1       1   2.095       0   19.65       0       0       0       1
 P      0    18.5      98     116     126     146
 T      0       0       0       0       0       0       1     0.1
 W   2.88   0.625
 I      4       4       1
 K      1       2       0       0       0       0       1
 K1 CHANNEL ROUTE THRU AREA 3
 Y      0       0       0       1       1
 Y1     1       0       0       0       0       0      -1
 Y6   .08     .04     .08     770     800   15500   .0025
 Y7   100     800     200     790     300     780     400     770    1000     770
 Y7  1050     780    1100     790    1120     800
 K      0       3       0       0       0       0       1
 K1 SUB AREA 3 RUNOFF
 M      1       1   4.419       0   19.65       0       0       0       1
 P      0    18.5      98     116     126     146
 T      0       0       0       0       0       0       1     0.1
 W   2.76    .625
 I      9       9       1
 K      2       2       0       0       0       0       1
 K1 COMBINE 2 HYDROGRAPHS AT 2
 K      1       4       0       0       0       0       1
 K1 CHANNEL ROUTE INTO LAKE BONAPARTE (AREA 1 & 3)
 Y      0       0       0       1       1
 Y1     1       0       0       0       0       0      -1
 Y6   .08     .04     .08     768     800    3500   .00057
 Y7   100     800     200     790     300     780     400     768    2000     768
 Y7  2050     780    2100     790    2120     800
 K      0       2       0       0       0       0       1
 K1 SUB AREA 2 - RUNOFF
 M      1       1   2.707       0   19.65       0       0       0       1
 P      0    18.5      98     116     126     146
 T      0       0       0       0       0       0       1     0.1
 W   3.03    .625
 I      6       6       1
 K      1       4       0       0       0       0       1
 K1 CHANNEL ROUTE INTO LAKE BONAPARTE (AREA 2)
 Y      0       0       0       1       1
 Y1     1       0       0       0       0       0      -1
 Y6   .08     .04     .08     768     800    9000    .004
 Y7   100     800     150     790     200     780    1200     768    2200     768
 Y7  3000     780    3050     790    3100     800
 K      0       4       0       0       0       0       1
 K1 SUB AREA 4 - RUNOFF
```

```
M     1      1   10.43      0   19.65      0      0      0      1
P     0   18.5      98    116    126    146
T     0      0      0      0      0      0      1    0.1
W  3.96   .625
I    21     21      1
K     3      4      0      0      0      0      1
K1 COMBINE ALL INFLOW HYDROGRAPHS INTO LAKE BONAPARTE
K     1      5      0      0      0      0      1
K1 ROUTE THRU ALPINA DAM (LAKE BONAPARTE)
Y     0      0      0      1      1
Y1    1      0      0      0      0      0     -1
$S    0    277   2980   6509   7866   9223  10580  11938  13294  14652
$S 16009
$E 762.6    764  767.4    770    771    772    773    774    775    776
$E   777
$$ 767.5     70    3.2    1.5
$D   769   2.64    1.5    100
K     1      6      0      0      0      0      1
K1 CHANNEL ROUTE THRU AREA 5
Y     0      0      0      1      1
Y1    1      0      0      0      0      0     -1
Y6   .08    .04    .08    685    710  23000  .0036
Y7   100    710    150    700    200    690    250    685    550    685
Y7   600    690    650    700    700    710
K     0      5      0      0      0      0      1
K1 SUB AREA 5 RUNOFF
M     1      1   3.505      0   19.65      0      0      0      1
P     0   18.5      98    116    126    146
T     0      0      0      0      0      0      1    0.1
W  4.21   .625
I     7      7      1
K     2      6      0      0      0      0      1
K1 COMBINE FLOW AT POINT 6
K    99
A
A
A
A
A
1          79/05/15. 09.26.37.     NOS 1.1-L430/MAC        A2CJPR0      STANDARD          MCAUTO - BLDG. 101, 1005--CYBER 175
0
```

```
1**********
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION     JULY 1978
   LAST MODIFICATION  26 FEB 79
 **********
1                          PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                                RUNOFF HYDROGRAPH AT          1
                                ROUTE HYDROGRAPH TO           2
                                RUNOFF HYDROGRAPH AT          3
                                COMBINE  2 HYDROGRAPHS AT     2
                                ROUTE HYDROGRAPH TO           4
                                RUNOFF HYDROGRAPH AT          2
                                ROUTE HYDROGRAPH TO           4
                                RUNOFF HYDROGRAPH AT          4
                                COMBINE  3 HYDROGRAPHS AT     4
                                ROUTE HYDROGRAPH TO           5
                                ROUTE HYDROGRAPH TO           6
                                RUNOFF HYDROGRAPH AT          5
                                COMBINE  2 HYDROGRAPHS AT     6
                                END OF NETWORK


1**********
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION     JULY 1978
   LAST MODIFICATION  26 FEB 79
 **********

 RUN  DATE# 79/05/15.
      TIME# 09.26.42.


                  ALPINA (LAKE BONAPARTE)
                 HEC-1DB
                 PMF-DAM OVERTOPPING ANALYSIS

                                        JOB SPECIFICATION
          NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
          90       1       0       0       0       0       0       0       4       0
                                 JOPER     NWT   LROPT   TRACE
                                     5       0       0       0


                                MULTI-PLAN ANALYSES TO BE PERFORMED
                                    NPLAN= 1 NRTIO= 6 LRTIO= 1
                 RTIOS=    .20     .40     .50     .60     .80    1.00
```

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 1 RUNOFF - SNYDER'S METHOD

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.10	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

$ LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 2.88 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 4.00 QRCSN= 4.00 RTIOR= 1.00

UNIT HYDROGRAPH 15 END-OF-PERIOD ORDINATES, LAG= 2.86 HOURS, CP= .62 VOL= 1.00

51. 176. 282. 278. 199. 129. 83. 54. 35. 23.
15. 10. 6. 4. 3.

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	22.22	18.25	3.96	24939.
										(564.)(464.)(101.)(706.19)			

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTE THRU AREA 3

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0300	.0400	.0300	770.0	800.0	15500.	.00250

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

100.00 800.00 200.00 790.00 300.00 780.00 400.00 770.00 1000.00 770.00
1050.00 780.00 1100.00 790.00 1120.00 800.00

STORAGE	0.00	343.76	700.82	1071.19	1454.87	1851.85	2262.14	2685.74	3122.64	3572.35
	4036.37	4513.19	5003.32	5506.61	6021.13	6546.31	7082.12	7628.58	8185.69	8753.43
OUTFLOW	0.00	2408.18	7698.20	15240.24	24800.27	36249.88	49510.27	65325.53	83358.23	103189.33
	124781.94	148105.48	173134.76	199861.86	228274.57	258322.89	289988.04	323254.19	358107.94	394537.85
STAGE	770.00	771.58	773.16	774.74	776.32	777.89	779.47	781.05	782.63	784.21
	785.79	787.37	788.95	790.53	792.11	793.68	795.26	796.84	798.42	800.00
FLOW	0.00	2408.18	7698.20	15240.24	24800.27	36249.88	49510.27	65325.53	83358.23	103189.33
	124781.94	148105.48	173134.76	199861.86	228274.57	258322.89	289988.04	323254.19	358107.94	394537.85

MAXIMUM STAGE IS 770.4

MAXIMUM STAGE IS 770.7

MAXIMUM STAGE IS 770.9

MAXIMUM STAGE IS 771.1

MAXIMUM STAGE IS 771.4

MAXIMUM STAGE IS 771.7

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 3 RUNOFF

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	4.42	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 2.76 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 9.00 QRCSN= 9.00 RTIOR= 1.00

UNIT HYDROGRAPH 15 END-OF-PERIOD ORDINATES, LAG= 2.75 HOURS, CP= .62 VOL= 1.00

119. 404. 616. 561. 383. 255. 170. 114. 76. 51.
34. 23. 15. 10. 7.

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	22.22	18.25	3.96	52590.
										(564.)	(464.)	(101.)	(1489.18)

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINE 2 HYDROGRAPHS AT 2

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	2	0	0	0	0	1	0	0

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTE INTO LAKE BONAPARTE (AREA 1 & 3)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0800	.0400	.0800	768.0	800.0	3500.	.00057

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

100.00 800.00 200.00 790.00 300.00 780.00 400.00 768.00 2000.00 768.00
2050.00 780.00 2100.00 790.00 2120.00 800.00

STORAGE	0.00	217.94	438.74	662.38	888.87	1118.21	1350.40	1585.43	1823.54	2065.06
	2309.99	2558.35	2810.13	3065.32	3323.63	3584.68	3848.46	4114.98	4384.23	4656.22
OUTFLOW	0.00	3399.53	10815.91	21305.63	34489.66	50140.15	68100.51	88255.05	111193.49	136344.61
	163556.35	192775.92	223957.60	257061.62	292069.73	328927.39	367601.69	408064.46	450290.51	494257.07
STAGE	768.00	769.68	771.37	773.05	774.74	776.42	778.11	779.79	781.47	783.16
	784.84	786.53	788.21	789.89	791.58	793.26	794.95	796.63	798.32	800.00
FLOW	0.00	3399.53	10815.91	21305.63	34489.66	50140.15	68100.51	88255.05	111193.49	136344.61
	163556.35	192775.92	223957.60	257061.62	292069.73	328927.39	367601.69	408064.46	450290.51	494257.07

MAXIMUM STAGE IS 768.9

MAXIMUM STAGE IS 769.7

MAXIMUM STAGE IS 770.0

MAXIMUM STAGE IS 770.2

MAXIMUM STAGE IS 770.6

MAXIMUM STAGE IS 771.0

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 2 - RUNOFF

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.71	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 3.03 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 6.00 QRCSN= 6.00 RTIOR= 1.00

UNIT HYDROGRAPH 16 END-OF-PERIOD ORDINATES, LAG= 3.03 HOURS, CP= .63 VOL= 1.00

57.	197.	329.	351.	271.	181.	120.	80.	53.	36.
24.	16.	11.	7.	5.	3.				

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	22.22	18.25	3.96	32298.
										(564.)(464.)(101.)(914.58)			

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTE INTO LAKE BONAPARTE (AREA 2)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0800	.0400	.0800	768.0	800.0	9000.	.00400

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

100.00 800.00 150.00 790.00 200.00 780.00 1200.00 768.00 2200.00 768.00
3000.00 780.00 3050.00 790.00 3100.00 800.00

STORAGE	0.00	391.93	871.77	1439.53	2095.19	2838.76	3670.25	4589.64	5565.53	6547.93
	7536.18	8530.30	9530.28	10536.11	11547.81	12565.37	13588.79	14618.07	15653.21	16694.21
OUTFLOW	0.00	5893.36	19761.60	41107.90	70261.59	107718.25	154025.23	209744.83	286865.28	375463.21
	473431.92	580383.00	695992.13	819982.68	952115.71	1092181.85	1239995.80	1395392.09	1558221.84	1728350.23
STAGE	768.00	769.68	771.37	773.05	774.74	776.42	778.11	779.79	781.47	783.16
	784.84	786.53	788.21	789.89	791.58	793.26	794.95	796.63	798.32	800.00
FLOW	0.00	5893.36	19761.60	41107.90	70261.59	107718.25	154025.23	209744.83	286865.28	375463.21
	473431.92	580383.00	695992.13	819982.68	952115.71	1092181.85	1239995.80	1395392.09	1558221.84	1728350.23

MAXIMUM STAGE IS 768.2

MAXIMUM STAGE IS 768.4

MAXIMUM STAGE IS 768.5

MAXIMUM STAGE IS 768.7

MAXIMUM STAGE IS 768.9

MAXIMUM STAGE IS 769.1

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 4 - RUNOFF

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	10.43	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 3.96 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 21.00 QRCSN= 21.00 RTIOR= 1.00

UNIT HYDROGRAPH 21 END-OF-PERIOD ORDINATES, LAG= 3.92 HOURS, CP= .62 VOL= 1.00

120.	429.	797.	1047.	1044.	846.	628.	467.	347.	258.
191.	142.	106.	79.	58.	43.	32.	24.	18.	13.
10.									

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	22.22	18.25	3.96	124163.
										(564.)	(464.)	(101.)	(3515.90)

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINE ALL INFLOW HYDROGRAPHS INTO LAKE BONAPARTE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	3	0	0	0	0	1	0	0

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE THRU ALPINA DAM (LAKE BONAPARTE)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

CAPACITY=	0.	277.	2980.	6509.	7866.	9223.	10580.	11938.	13294.	14652.
	16009.									
ELEVATION=	763.	764.	767.	770.	771.	772.	773.	774.	775.	776.
	777.									

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
767.5	70.0	3.2	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
769.0	2.6	1.5	100.

PEAK OUTFLOW IS 78. AT TIME 58.00 HOURS

PEAK OUTFLOW IS 1338. AT TIME 52.00 HOURS

PEAK OUTFLOW IS 2377. AT TIME 50.00 HOURS

PEAK OUTFLOW IS 3541. AT TIME 50.00 HOURS

PEAK OUTFLOW IS 6117. AT TIME 49.00 HOURS

PEAK OUTFLOW IS 8923. AT TIME 48.00 HOURS

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTE THRU AREA 5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
6	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0800	.0400	.0800	685.0	710.0	23000.	.00360

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

100.00 710.00 150.00 700.00 200.00 690.00 250.00 685.00 550.00 685.00
600.00 690.00 650.00 700.00 700.00 710.00

STORAGE	0.00	217.57	453.41	707.54	979.78	1264.07	1557.51	1860.09	2171.81	2492.68
	2822.68	3161.83	3510.12	3867.54	4234.11	4609.83	4994.68	5388.67	5791.81	6204.09
OUTFLOW	0.00	1075.60	3472.21	6946.73	11522.76	17482.77	24428.33	32316.08	41113.31	50794.77
	61340.51	72734.60	84964.13	98018.56	111889.29	126569.26	142052.70	158334.92	175412.14	193281.36
STAGE	685.00	686.32	687.63	688.95	690.26	691.58	692.89	694.21	695.53	696.84
	698.16	699.47	700.79	702.11	703.42	704.74	706.05	707.37	708.68	710.00
FLOW	0.00	1075.60	3472.21	6946.73	11522.76	17482.77	24428.33	32316.08	41113.31	50794.77
	61340.51	72734.60	84964.13	98018.56	111889.29	126569.26	142052.70	158334.92	175412.14	193281.36

MAXIMUM STAGE IS 685.1

MAXIMUM STAGE IS 686.4

MAXIMUM STAGE IS 687.0

MAXIMUM STAGE IS 687.6

MAXIMUM STAGE IS 688.6

MAXIMUM STAGE IS 689.5

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 5 RUNOFF

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	3.51	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 4.21 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 7.00 QRCSN= 7.00 RTIOR= 1.00

UNIT HYDROGRAPH 23 END-OF-PERIOD ORDINATES, LAG= 4.21 HOURS, CP= .62 VOL= 1.00

33.	118.	225.	308.	330.	288.	221.	170.	131.	101.
77.	60.	46.	35.	27.	21.	16.	12.	9.	7.
6.	4.	3.							

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	22.22	18.25	3.96	41692.
										(564.)	(464.)	(101.)	(1180.59)

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINE FLOW AT POINT 6

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
6	2	0	0	0	0	1	0	0

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO APPLIED TO FLOWS RATIO 1 .20	RATIO 2 .40	RATIO 3 .50	RATIO 4 .60	RATIO 5 .80	RATIO 6 1.00
HYDROGRAPH AT	1	2.10	1	638.	1277.	1596.	1915.	2554.	3192.
	(	5.43)	(	18.08)(	36.16)(	45.20)(	54.24)(	72.31)(	90.39)(
ROUTED TO	2	2.10	1	548.	1096.	1370.	1644.	2191.	2868.
	(	5.43)	(	15.51)(	31.03)(	38.79)(	46.54)(	62.06)(	81.22)(
HYDROGRAPH AT	3	4.42	1	1359.	2718.	3397.	4076.	5435.	6794.
	(	11.45)	(	38.48)(	76.95)(	96.19)(	115.43)(	153.91)(	192.38)(
2 COMBINED	2	6.51	1	1836.	3673.	4591.	5509.	7346.	9314.
	(	16.87)	(	52.00)(	104.01)(	130.01)(	156.01)(	208.01)(	263.75)(
ROUTED TO	4	6.51	1	1739.	3515.	4632.	5505.	7333.	9251.
	(	16.87)	(	49.24)(	99.54)(	131.16)(	155.88)(	207.64)(	261.97)(
HYDROGRAPH AT	2	2.71	1	810.	1621.	2026.	2431.	3241.	4051.
	(	7.01)	(	22.94)(	45.89)(	57.36)(	68.83)(	91.78)(	114.72)(
ROUTED TO	4	2.71	1	759.	1517.	1897.	2276.	3035.	3793.
	(	7.01)	(	21.48)(	42.97)(	53.71)(	64.45)(	85.94)(	107.42)(
HYDROGRAPH AT	4	10.43	1	2635.	5270.	6587.	7905.	10540.	13174.
	(	27.01)	(	74.61)(	149.22)(	186.53)(	223.84)(	298.45)(	373.06)(
3 COMBINED	4	19.65	1	5132.	10302.	13116.	15686.	20907.	26219.
	(	50.90)	(	145.33)(	291.73)(	371.40)(	444.17)(	592.02)(	742.45)(
ROUTED TO	5	19.65	1	78.	1338.	2377.	3541.	6117.	8923.
	(	50.90)	(	2.20)(	37.90)(	67.30)(	100.28)(	173.23)(	252.68)(
ROUTED TO	6	19.65	1	76.	1297.	2329.	3463.	6034.	8845.
	(	50.90)	(	2.14)(	36.73)(	65.96)(	98.07)(	170.87)(	250.45)(
HYDROGRAPH AT	5	3.51	1	840.	1680.	2099.	2519.	3359.	4199.
	(	9.08)	(	23.78)(	47.56)(	59.45)(	71.34)(	95.12)(	118.90)(
2 COMBINED	6	23.16	1	840.	1721.	2800.	4121.	7206.	10606.
	(	59.97)	(	23.78)(	48.74)(	79.28)(	116.70)(	204.05)(	300.34)(

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.20	548.	770.4	44.00
.40	1096.	770.7	44.00
.50	1370.	770.9	44.00
.60	1644.	771.1	44.00
.80	2191.	771.4	44.00
1.00	2868.	771.7	44.00

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.20	1739.	768.9	43.00
.40	3515.	769.7	43.00
.50	4632.	770.0	43.00
.60	5505.	770.2	43.00
.80	7333.	770.6	43.00
1.00	9251.	771.0	43.00

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.20	759.	768.2	43.00
.40	1517.	768.4	43.00
.50	1897.	768.5	43.00
.60	2276.	768.7	43.00
.80	3035.	768.9	43.00
1.00	3793.	769.1	43.00

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	762.60	767.50	769.00
STORAGE	0.	3116.	5152.
OUTFLOW	0.	0.	412.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	767.99	0.00	3785.	78.	0.00	58.00	0.00
.40	770.20	1.20	6777.	1338.	36.00	52.00	0.00
.50	771.14	2.14	8850.	2377.	46.00	50.00	0.00
.60	772.02	3.02	9253.	3541.	48.00	50.00	0.00
.80	773.68	4.68	11506.	6117.	49.00	49.00	0.00
1.00	775.23	6.23	13609.	8923.	50.00	48.00	0.00

PLAN 1 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.20	76.	685.1	62.00
.40	1297.	686.4	54.00
.50	2329.	687.0	52.00
.60	3463.	687.6	51.00
.80	6034.	688.6	50.00
1.00	8845.	689.5	49.00

1**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
****

```
1A1   ALPINA (LAKE BONAPARTE)
 A2   HEC-1DB
 A3   PMF-DAM DAM BREAK ANALYSIS
 B     90      0      15      0      0      0      0      0      4
 B1     5
 J      3      2       1
 J1    .5    1.0
 K      0      1       0      0      0      0      1
 K1 SUB AREA 1 RUNOFF - SNYDER'S METHOD
 M      1      1   2.095      0  19.65      0      0      0      1
 P      0   18.5      98    116    126    146
 T      0      0       0      0      0      0      1    0.1
 W   2.88  0.625
 X      4      4       1
 K      1      2       0      0      0      0      1
 K1 CHANNEL ROUTE THRU AREA 3
 Y      0      0       0      1      1
 Y1     1      0       0      0      0      0     -1
 Y6   .08    .04     .08    770    800  15500  .0025
 Y7   100    800     200    790    300    780    400    770   1000    770
 Y7  1050    780    1100    790   1120    800
 K      0      3       0      0      0      0      1
 K1 SUB AREA 3 RUNOFF
 M      1      1   4.419      0  19.65      0      0      0      1
 P      0   18.5      98    116    126    146
 T      0      0       0      0      0      0      1    0.1
 W   2.76   .625
 X      9      9       1
 K      2      2       0      0      0      0      1
 K1 COMBINE 2 HYDROGRAPHS AT 2
 K      1      4       0      0      0      0      1
 K1 CHANNEL ROUTE INTO LAKE BONAPARTE (AREA 1 & 3)
 Y      0      0       0      1      1
 Y1     1      0       0      0      0      0     -1
 Y6   .08    .04     .08    768    800   3500  .00057
 Y7   100    800     200    790    300    780    400    768   2000    768
 Y7  2050    780    2100    790   2120    800
 K      0      2       0      0      0      0      1
 K1 SUB AREA 2 - RUNOFF
 M      1      1   2.707      0  19.65      0      0      0      1
 P      0   18.5      98    116    126    146
 T      0      0       0      0      0      0      1    0.1
 W   3.03   .625
 X      6      6       1
 K      1      4       0      0      0      0      1
 K1 CHANNEL ROUTE INTO LAKE BONAPARTE (AREA 2)
 Y      0      0       0      1      1
 Y1     1      0       0      0      0      0     -1
 Y6   .08    .04     .08    768    800   9000   .004
 Y7   100    800     150    790    200    780   1200    768   2200    768
 Y7  3000    780    3050    790   3100    800
 K      0      4       0      0      0      0      1
 K1 SUB AREA 4 - RUNOFF
 M      1      1   10.43      0  19.65      0      0      0      1
 P      0   18.5      98    116    126    146
```

```
T      0       0       0       0       0       0       1     0.1
W   3.96    .625
X     21      21       1
K      3       4       0       0       0       0       1
K1 COMBINE ALL INFLOW HYDROGRAPHS INTO LAKE BONAPARTE
K      1       5       0       0       0       0       1
K1 ROUTE THRU ALPINA DAM (LAKE BONAPARTE)
Y      0       0       0       1       1
Y1     1       0       0       0       0       0      -1
$S     0     277    2980    6509    7866    9223   10580   11938   13294   14652
$S 16009
$E 761.8     764   767.4     770     771     772     773     774     775     776
$E   777
$$ 767.5      70     3.2     1.5
$D   769    2.64     1.5     100
$B    75       1   761.8       2  767.50  769.50
$B    75       1   761.8       4  767.50  769.50
$B    75       1   761.8       6  767.50  769.50
K      1       6       0       0       0       0       1
K1 CHANNEL ROUTE THRU AREA 5
Y      0       0       0       1       1
Y1     1       0       0       0       0       0      -1
Y6   .08     .04     .08     685     710   23000   .0036
Y7   100     710     150     700     200     690     250     685     550     685
Y7   600     690     650     700     700     710
K      0       5       0       0       0       0       1
K1 SUB AREA 5 RUNOFF
M      1       1   3.505       0   19.65       0       0       0       1
P      0    18.5      98     116     126     146
T      0       0       0       0       0       0       1     0.1
W   4.21    .625
X      7       7       1
K      2       6       0       0       0       0       1
K1 COMBINE FLOW AT POINT 6
K     99
A
```

```
1**********
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION     JULY 1978
   LAST MODIFICATION  26 FEB 79
 **********
1                          PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

                                RUNOFF HYDROGRAPH AT          1
                                ROUTE HYDROGRAPH TO           2
                                RUNOFF HYDROGRAPH AT          3
                                COMBINE  2 HYDROGRAPHS AT     2
                                ROUTE HYDROGRAPH TO           4
                                RUNOFF HYDROGRAPH AT          2
                                ROUTE HYDROGRAPH TO           4
                                RUNOFF HYDROGRAPH AT          4
                                COMBINE  3 HYDROGRAPHS AT     4
                                ROUTE HYDROGRAPH TO           5
                                ROUTE HYDROGRAPH TO           6
                                RUNOFF HYDROGRAPH AT          5
                                COMBINE  2 HYDROGRAPHS AT     6
                                END OF NETWORK


1**********
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION     JULY 1978
   LAST MODIFICATION  26 FEB 79
 **********

 RUN  DATE# 79/05/18.
      TIME# 07.19.59.


                  ALPINA (LAKE BONAPARTE)
                 HEC-1DB
                 PMF-DAM DAM BREAK ANALYSIS

                                    JOB SPECIFICATION
      NQ     NHR     NMIN     IDAY     IHR     IMIN    METRC     IPLT     IPRT    NSTAN
      90      0       15        0       0        0       0        0        4        0
                             JOPER     NWT    LROPT    TRACE
                                 5       0        0        0


                            MULTI-PLAN ANALYSES TO BE PERFORMED
                                NPLAN= 3 NRTIO= 2 LRTIO= 1
          RTIOS=     .50   1.00
```

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 1 RUNOFF - SNYDER'S METHOD

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.10	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 2.88 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 4.00 QRCSN= 4.00 RTIOR= 1.00

UNIT HYDROGRAPH 63 END-OF-PERIOD ORDINATES, LAG= 2.86 HOURS, CP= .63 VOL= 1.00

8.	28.	57.	91.	128.	167.	206.	242.	269.	289.
301.	304.	295.	275.	250.	227.	206.	188.	170.	155.
141.	128.	116.	106.	96.	87.	80.	72.	66.	60.
54.	49.	45.	41.	37.	34.	31.	28.	25.	23.
21.	19.	17.	16.	14.	13.	12.	11.	10.	9.
8.	7.	7.	6.	6.	5.	5.	4.	4.	3.
3.	3.	3.							

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	22.22	18.25	3.96	92567.
										(564.)	(464.)	(101.)	(2621.21)

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTE THRU AREA 3

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0300	.0400	.0300	770.0	800.0	15500.	.00250

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
100.00 800.00 200.00 790.00 300.00 780.00 400.00 770.00 1000.00 770.00
1050.00 780.00 1100.00 790.00 1120.00 800.00

STORAGE	0.00	343.76	700.82	1071.19	1454.87	1851.85	2262.14	2685.74	3122.64	3572.85
	4036.37	4513.19	5003.32	5506.61	6021.13	6546.31	7082.12	7628.58	8185.69	8753.44
OUTFLOW	0.00	2408.18	7698.20	15240.24	24800.27	36249.88	49510.27	65325.53	83358.23	103189.33
	124781.94	148105.48	173134.76	199861.86	228274.57	258322.89	289988.04	323254.19	358107.94	394537.85
STAGE	770.00	771.58	773.16	774.74	776.32	777.89	779.47	781.05	782.63	784.21
	785.79	787.37	788.95	790.53	792.11	793.68	795.26	796.84	798.42	800.00
FLOW	0.00	2408.18	7698.20	15240.24	24800.27	36249.88	49510.27	65325.53	83358.23	103189.33
	124781.94	148105.48	173134.76	199861.86	228274.57	258322.89	289988.04	323254.19	358107.94	394537.85

MAXIMUM STAGE IS 770.9

MAXIMUM STAGE IS 771.7

MAXIMUM STAGE IS 770.9

MAXIMUM STAGE IS 771.7

MAXIMUM STAGE IS 770.9

MAXIMUM STAGE IS 771.7

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 3 RUNOFF

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	4.42	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 2.76 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 9.00 QRCSN= 9.00 RTIOR= 1.00

UNIT HYDROGRAPH 62 END-OF-PERIOD ORDINATES, LAG= 2.78 HOURS, CP= .63 VOL= 1.00

17.	65.	132.	210.	295.	384.	472.	548.	605.	642.
661.	656.	619.	564.	512.	464.	422.	382.	347.	315.
286.	259.	235.	214.	194.	176.	160.	145.	131.	119.
108.	98.	89.	81.	73.	67.	60.	55.	50.	45.
41.	37.	34.	31.	28.	25.	23.	21.	19.	17.
16.	14.	13.	12.	11.	10.	9.	8.	7.	6.
6.	5.								

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	22.22	18.25	3.96	196372.
										(564.)	(464.)	(101.)	(5560.64)

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINE 2 HYDROGRAPHS AT 2

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	2	0	0	0	0	1	0	0

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTE INTO LAKE BONAPARTE (AREA 1 & 3)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0800	.0400	.0800	768.0	800.0	3500.	.00057

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
100.00 800.00 200.00 790.00 300.00 780.00 400.00 768.00 2000.00 768.00
2050.00 780.00 2100.00 790.00 2120.00 800.00

STORAGE	0.00	217.94	438.74	662.38	888.87	1118.21	1350.40	1585.43	1823.54	2065.06
	2309.99	2558.35	2810.13	3065.32	3323.63	3584.68	3848.46	4114.98	4384.23	4656.22
OUTFLOW	0.00	3399.53	10815.91	21305.63	34489.66	50140.15	68100.51	88255.05	111193.49	136344.61
	163556.35	192775.92	223957.60	257061.62	292069.73	328927.39	367601.69	408064.46	450290.51	494257.07
STAGE	768.00	769.68	771.37	773.05	774.74	776.42	778.11	779.79	781.47	783.16
	784.84	786.53	788.21	789.89	791.58	793.26	794.95	796.63	798.32	800.00
FLOW	0.00	3399.53	10815.91	21305.63	34489.66	50140.15	68100.51	88255.05	111193.49	136344.61
	163556.35	192775.92	223957.60	257061.62	292069.73	328927.39	367601.69	408064.46	450290.51	494257.07

MAXIMUM STAGE IS 770.0

MAXIMUM STAGE IS 771.0

MAXIMUM STAGE IS 770.0

MAXIMUM STAGE IS 771.0

MAXIMUM STAGE IS 770.0

MAXIMUM STAGE IS 771.0

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 2 - RUNOFF

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	2.71	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 3.03 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 6.00 QRCSN= 6.00 RTIOR= 1.00

UNIT HYDROGRAPH 68 END-OF-PERIOD ORDINATES, LAG= 3.04 HOURS, CP= .63 VOL= 1.00

9.	32.	65.	104.	147.	192.	238.	281.	317.	344.
361.	370.	368.	350.	322.	295.	270.	247.	226.	207.
190.	173.	159.	145.	133.	122.	111.	102.	93.	86.
78.	72.	66.	60.	55.	50.	46.	42.	39.	35.
32.	30.	27.	25.	23.	21.	19.	17.	16.	15.
13.	12.	11.	10.	9.	9.	8.	7.	7.	6.
6.	5.	5.	4.	4.	4.	3.	3.		

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

SUM	22.22	18.25	3.96	118036.
	(564.)	(464.)	(101.)	(3342.41)

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTE INTO LAKE BONAPARTE (AREA 2)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0800	.0400	.0800	768.0	800.0	9000.	.00400

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

100.00 800.00 150.00 790.00 200.00 780.00 1200.00 768.00 2200.00 768.00
3000.00 780.00 3050.00 790.00 3100.00 800.00

STORAGE	0.00	391.93	871.77	1439.53	2095.19	2838.76	3670.25	4589.64	5565.53	6547.93
	7536.18	8530.30	9530.28	10536.11	11547.81	12565.37	13588.79	14618.07	15653.21	16694.21
OUTFLOW	0.00	5893.36	19761.60	41107.90	70261.59	107718.25	154025.23	209744.83	286865.28	375463.21
	473431.92	580383.00	695992.13	819982.68	952115.71	1092181.85	1239995.80	1395392.09	1558221.84	1728350.23
STAGE	768.00	769.68	771.37	773.05	774.74	776.42	778.11	779.79	781.47	783.16
	784.84	786.53	788.21	789.89	791.58	793.26	794.95	796.63	798.32	800.00
FLOW	0.00	5893.36	19761.60	41107.90	70261.59	107718.25	154025.23	209744.83	286865.28	375463.21
	473431.92	580383.00	695992.13	819982.68	952115.71	1092181.85	1239995.80	1395392.09	1558221.84	1728350.23

MAXIMUM STAGE IS 768.5

MAXIMUM STAGE IS 769.1

MAXIMUM STAGE IS 768.5

MAXIMUM STAGE IS 769.1

MAXIMUM STAGE IS 768.5

MAXIMUM STAGE IS 769.1

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 4 - RUNOFF

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	10.43	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 3.96 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 21.00 QRCSN= 21.00 RTIOR= 1.00

UNIT HYDROGRAPH 87 END-OF-PERIOD ORDINATES, LAG= 3.95 HOURS, CP= .63 VOL= 1.00

17.	65.	134.	214.	304.	399.	500.	604.	711.	812.
900.	972.	1029.	1070.	1095.	1103.	1091.	1049.	985.	919.
858.	801.	748.	699.	652.	609.	569.	531.	496.	463.
432.	403.	377.	352.	328.	306.	286.	267.	249.	233.
217.	203.	189.	177.	165.	154.	144.	134.	126.	117.
109.	102.	95.	89.	83.	78.	72.	68.	63.	59.
55.	51.	48.	45.	42.	39.	36.	34.	32.	30.
28.	26.	24.	23.	21.	20.	18.	17.	16.	15.
14.	13.	12.	11.	11.	10.	9.			

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

SUM	22.22	18.25	3.96	419117.
	(564.)	(464.)	(101.)	(11868.07)

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINE ALL INFLOW HYDROGRAPHS INTO LAKE BONAPARTE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	3	0	0	0	0	1	0	0

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE THRU ALPINA DAM (LAKE BONAPARTE)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

CAPACITY=	0.	277.	2980.	6509.	7866.	9223.	10580.	11938.	13294.	14652.
	16009.									
ELEVATION=	762.	764.	767.	770.	771.	772.	773.	774.	775.	776.
	777.									

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
767.5	70.0	3.2	1.5	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
769.0	2.6	1.5	100.

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
75.	1.00	761.80	2.00	767.50	769.50

BEGIN DAM FAILURE AT 41.75 HOURS

PEAK OUTFLOW IS 9022. AT TIME 45.75 HOURS

BEGIN DAM FAILURE AT 38.75 HOURS

PEAK OUTFLOW IS 16030. AT TIME 46.00 HOURS

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
75.	1.00	761.80	4.00	767.50	769.50

BEGIN DAM FAILURE AT 41.75 HOURS

PEAK OUTFLOW IS 9823. AT TIME 45.75 HOURS

BEGIN DAM FAILURE AT 38.75 HOURS

PEAK OUTFLOW IS 16587. AT TIME 46.00 HOURS

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
75.	1.00	761.80	6.00	767.50	769.50

BEGIN DAM FAILURE AT 41.75 HOURS

PEAK OUTFLOW IS 9825. AT TIME 47.75 HOURS

BEGIN DAM FAILURE AT 38.75 HOURS

PEAK OUTFLOW IS 17400. AT TIME 45.75 HOURS

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTE THRU AREA 5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
6	1	0	0	0	0	1	0	0

ALL PLANS HAVE SAME ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-1.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0800	.0400	.0800	685.0	710.0	23000.	.00360

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

100.00 710.00 150.00 700.00 200.00 690.00 250.00 685.00 550.00 685.00
600.00 690.00 650.00 700.00 700.00 710.00

STORAGE	0.00	217.57	453.41	707.54	979.78	1264.07	1557.51	1860.09	2171.81	2492.68
	2822.68	3161.83	3510.12	3867.54	4234.11	4609.83	4994.68	5388.67	5791.81	6204.09
OUTFLOW	0.00	1075.60	3472.21	6946.73	11522.76	17482.77	24428.33	32316.08	41113.31	50794.77
	61340.51	72734.60	84964.13	98018.56	111889.29	126569.26	142052.70	158334.92	175412.14	193281.36
STAGE	685.00	686.32	687.63	688.95	690.26	691.58	692.89	694.21	695.53	696.84
	698.16	699.47	700.79	702.11	703.42	704.74	706.05	707.37	708.68	710.00
FLOW	0.00	1075.60	3472.21	6946.73	11522.76	17482.77	24428.33	32316.08	41113.31	50794.77
	61340.51	72734.60	84964.13	98018.56	111889.29	126569.26	142052.70	158334.92	175412.14	193281.36

MAXIMUM STAGE IS 689.5

MAXIMUM STAGE IS 691.2

MAXIMUM STAGE IS 689.6

MAXIMUM STAGE IS 691.3

MAXIMUM STAGE IS 689.6

MAXIMUM STAGE IS 691.5

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

SUB AREA 5 RUNOFF

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	3.51	0.00	19.65	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	18.50	98.00	116.00	126.00	146.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .823

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 4.21 CP= .63 NTA= 0

RECESSION DATA

STRTQ= 7.00 QRCSN= 7.00 RTIOR= 1.00

UNIT HYDROGRAPH 93 END-OF-PERIOD ORDINATES, LAG= 4.19 HOURS, CP= .63 VOL= 1.00

5.	19.	39.	62.	89.	117.	146.	177.	209.	240.
269.	293.	313.	329.	340.	347.	349.	345.	333.	313.
294.	276.	258.	242.	227.	213.	200.	187.	176.	165.
154.	145.	136.	127.	119.	112.	105.	98.	92.	86.
81.	76.	71.	67.	63.	59.	55.	52.	48.	45.
43.	40.	37.	35.	33.	31.	29.	27.	25.	24.
22.	21.	20.	18.	17.	16.	15.	14.	13.	13.
12.	11.	10.	10.	9.	8.	8.	7.	7.	7.
6.	6.	5.	5.	5.	4.	4.	4.	4.	3.
3.	3.	3.							

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	22.22	18.25	3.96	137226.
										(564.)	(464.)	(101.)	(3885.81)

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINE FLOW AT POINT 6

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
6	2	0	0	0	0	1	0	0

```
e~~~ff~fgf!~~,?llx~xm~k
CAUTO  -  08:31    MAY 18,'79
OGON PLEASE: C0746,DAMS
ASSWORD
[redacted](

ID=322


#FAI334
RECOVERY IMPOSSIBLE.
#FAI 3.++++++FAI+ 334++++++
LLEGAL COMMAND.
#FAI 334
 FAI      NOT FOUND.
#FAILSAFE 334
 FAI      NOT FOUND.
#FAIL334
 FAI      NOT FOUND.
#FAI334
 FAI      NOT FOUND.
#LOGON



CON= 0:02 MRU=     1.000


MCAUTO  -  08:32    MAY 18,'79
OGON PLEASE: C0746,STET
ASSWORD
[redacted](

ID=322


#FAI:334

LAST COMMAND    = LIST
JOB STATUS      = OUTPUT AVAILABLE.
NEXT OPERATION  = CONTINUE.

TO COMPLETE THE RECOVERY PROCEDURE AND CONTINUE
FROM WHERE YOU WERE IN THE PREVIOUS SESSION YOU
MUST TYPE A CARRIAGE RETURN AT THE PROMPT BELOW.
?
FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
                                FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
                                      AREA IN SQUARE MILES (SQUARE KILOMETERS)

                                                                  RATIOS APPLIED TO FLOWS
 OPERATION     STATION      AREA     PLAN  RATIO 1   RATIO 2
                                                .50       1.00


 HYDROGRAPH AT       1      2.10       1     1633.     3267.
                     (     5.43)        (   46.25)(   92.51)(
                                      2     1633.     3267.
                                       (   46.25)(   92.51)(
                                      3     1633.     3267.
                                       (   46.25)(   92.51)(
```

ROUTED TO	2	2.18	1	1353.	2868.
	(	5.43)	(	38.31) (	80.98) (
			2	1353.	2868.
			(	38.31) (	80.98) (
			3	1353.	2868.
			(	38.31) (	80.98) (
HYDROGRAPH AT	3	4.42	1	3495.	6998.
	(	11.45)	(	98.97) (	197.95) (
			2	3495.	6998.
			(	98.97) (	197.95) (
			3	3495.	6998.
			(	98.97) (	197.95) (
2 COMBINED	2	6.51	1	4685.	9425.
	(	16.87)	(	132.67) (	266.89) (
			2	4685.	9425.
			(	132.67) (	266.89) (
			3	4685.	9425.
			(	132.67) (	266.89) (
ROUTED TO	4	6.51	1	4601.	9388.
	(	16.87)	(	130.28) (	263.34) (
			2	4601.	9388.
			(	130.28) (	263.34) (
			3	4601.	9388.
			(	130.28) (	263.34) (
HYDROGRAPH AT	2	2.71	1	2034.	4068.
	(	7.01)	(	57.60) (	115.20) (
			2	2034.	4068.
			(	57.60) (	115.20) (
			3	2034.	4068.
			(	57.60) (	115.20) (
ROUTED TO	4	2.71	1	1913.	3827.
	(	7.01)	(	54.18) (	108.37) (
			2	1913.	3827.
			(	54.18) (	108.37) (
			3	1913.	3827.
			(	54.18) (	108.37) (
HYDROGRAPH AT	4	10.43	1	6673.	13346.
	(	27.01)	(	188.96) (	377.92) (
			2	6673.	13346.
			(	188.96) (	377.92) (
			3	6673.	13346.
			(	188.96) (	377.92) (
3 COMBINED	4	19.65	1	13146.	26425.
	(	50.90)	(	372.24) (	748.27) (
			2	13146.	26425.
			(	372.24) (	748.27) (
			3	13146.	26425.
			(	372.24) (	748.27) (
ROUTED TO	5	19.65	1	9822.	16838.
	(	50.90)	(	255.47) (	453.93) (
			2	9823.	16587.
			(	278.16) (	469.70) (
			3	9825.	17488.
			(	278.23) (	492.70) (

ROUTED TO	6	19.65	1	8858.	15882.
	(	50.90)	(	250.82) (	449.74) (
			2	9325.	16439.
			(	264.05) (	465.50) (
			3	9259.	17183.
			(	262.18) (	486.58) (
HYDROGRAPH AT	5	3.51	1	2154.	4307.
	(	9.08)	(	60.99) (	121.97) (
			2	2154.	4307.
			(	60.99) (	121.97) (
			3	2154.	4307.
			(	60.99) (	121.97) (
2 COMBINED	6	23.16	1	10232.	18743.
	(	59.97)	(	289.74) (	530.74) (
			2	10495.	19378.
			(	297.18) (	548.74) (
			3	10195.	20105.
			(	288.69) (	569.31) (

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	1353.	770.9	43.75
1.00	2860.	771.7	43.50

PLAN 2 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	1353.	770.9	43.75
1.00	2860.	771.7	43.50

PLAN 3 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	1353.	770.9	43.75
1.00	2860.	771.7	43.50

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	4601.	770.0	43.00
1.00	9300.	771.0	43.00

PLAN 2 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	4601.	770.0	43.00
1.00	9300.	771.0	43.00

PLAN 3 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	4601.	770.0	43.00
1.00	9300.	771.0	43.00

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	1913.	768.5	43.25
1.00	3827.	769.1	43.25

PLAN 2 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	1913.	768.5	43.25
1.00	3827.	769.1	43.25

PLAN 3 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	1913.	768.5	43.25
1.00	3827.	769.1	43.25

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	767.50	767.50	769.00
STORAGE	3116.	3116.	5152.
OUTFLOW	0.	0.	412.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	770.89	1.89	7716.	9022.	7.75	45.75	41.75
1.00	773.45	4.45	11185.	16030.	11.50	46.00	38.75

PLAN 2 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	767.50	767.50	769.00
STORAGE	3116.	3116.	5152.
OUTFLOW	0.	0.	412.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	771.23	2.23	8173.	9823.	7.75	45.75	41.75
1.00	773.62	4.62	11429.	16587.	11.50	46.00	38.75

PLAN 3 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	767.50	767.50	769.00
STORAGE	3116.	3116.	5152.
OUTFLOW	0.	0.	412.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	771.47	2.47	8500.	9825.	7.75	47.75	41.75
1.00	773.88	4.88	11778.	17400.	11.50	45.75	38.75

PLAN 1 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	8858.	689.5	46.75
1.00	15882.	691.2	46.75

PLAN 2 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	9325.	689.6	47.25
1.00	16439.	691.3	46.50

PLAN 3 STATION 6

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	9259.	689.6	48.00
1.00	17183.	691.5	46.50

```
1**********************************
 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAM SAFETY VERSION      JULY 1978
   LAST MODIFICATION  26 FEB 79
 **********************************
#
```

APPENDIX D

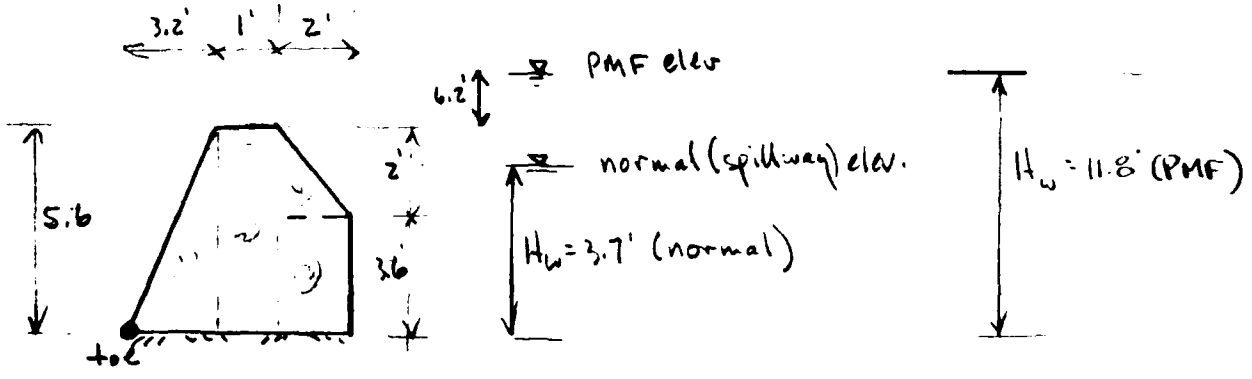
STABILITY ANALYSIS

ALPINA DAM

STABILITY ANALYSIS - OVERTURNING & SLIDING

low hazard class.
seismic zone 2
use ice force = 5K/ft

assumed x-section



note: neglect downward wt. of water acting on upstream slope face of dam

I. Overturning

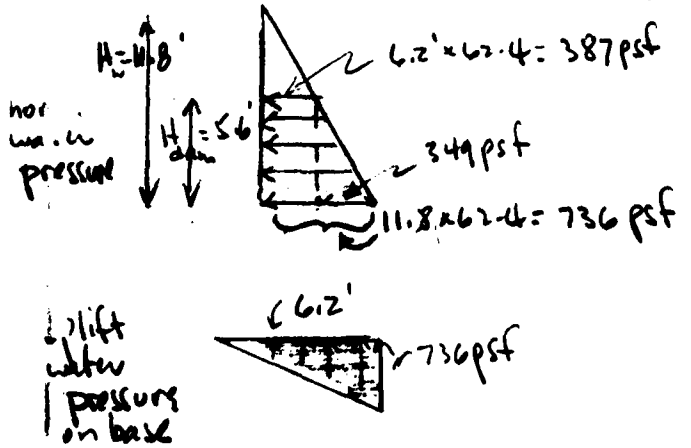
(a) WL @ PMF elevation, uplift on 100% of base, no ice

(i) moments about toe, resisting (mass of dam):

$= \frac{2}{3}\times 32\left(\frac{1}{2}\times 3.2\times 5.6\times .15\right) + (1\times 5.6\times .15\times 3.7) + \left(2\times 5.6\times .15\times 5.2\right) + \left(\frac{2}{2}\times 2\times .15\times 4.8\right)$

$= 2.86 + 3.11 + 5.62 + 1.46 = 13.05^{1K}$

(ii) moments causing ovt: horiz. water press + uplift. water press.



$= \left(.387\times 5.6\times \frac{5.6}{2}\right) + \left(.349\times \frac{5.6}{2}\times \frac{5.6}{3}\right) +$

$+ \left(.736\times \frac{6.2}{2}\times \frac{2}{3}\times 6.2\right) = 6.07 + 1.82 + 9.4$

$= 17.3^{1K}$

FS against overturning =

$= \frac{13.05^{1K}}{7.9^{1K}} = 1.65$ (no uplift)

$= \frac{13.05}{17.3} = 0.75$ ± (assumed uplift acting)

(b) WL @ spillway level, uplift on 100% of base, ice exists

(i) resisting moment = 13.05^{1K}

(ii) moments causing ovt: horiz. water pressure + uplift + ice =

$$= \left(3.7 \times 62.4 \times \frac{3.7}{2} \times \frac{3.7}{3}\right) + \left(3.7 \times 62.4 \times \frac{6.2}{2} \times \frac{2}{3} \times 6.2\right) + \left(5^{k} \times 4'\right)$$

$$= 0.53^{1K} + 2.96^{1K} + 20^{1K}$$

FS against overturning =

$= \frac{13.05^{1K}}{0.53^{1K}} = 25 \pm$ (no uplift, no ice) -ok-

$= \frac{13.05}{3.5} = 3.7 \pm$ (uplift, no ice) -ok-

$= \frac{13.05}{23.5} = 0.55 \pm$ (uplift, ice acting) -low-

$= \frac{13.05}{20.53} = 0.64 \pm$ (no uplift, ice acting)

II. Sliding

(a) WL @ PMF elevation, uplift on 100% of base

(i) wt. of dam: $\left(\frac{1}{2} \times 3.2 \times 5.6 \times .15\right) + \left(1 \times 5.6 \times .15\right) + \left(3.6 \times 2 \times .15\right) + \left(\frac{1}{2} \times 2 \times 2 \times .15\right) = 1.34 + 0.84 + 1.08 + 0.30 = 3.56^{k}$

(ii) lateral water pressure behind dam:
$= \left(\frac{0.387 + 0.736}{2}\right)(5.6) = 2.45^{k}$

(iii) uplift on dam base $= \frac{0.736 \times 6.2}{2} = 2.28^{k}$

FS against sliding (friction-shear method, assume that 50 psi bond/shear develops between concrete dam and rock foundation; $\mu_{friction} = 0.65$)

$$= \frac{\mu N + \text{bond/shear}}{\text{lateral water press}} = \frac{(0.65)(3.56 - 2.28) + (0.05 \times 144 \times 6.2}{2.45}$$

$$= \frac{0.83^{k} + 44.6^{k}}{2.45^{k}} = 18 \pm \quad \text{-ok-}$$

(b) WL @ spillway elevation, uplift and ice acting

(i) wt. of dam: 3.56^{k}

(ii) lateral water pressure behind dam: $3.7 \times 62.4 \times \frac{3.7}{2} = 0.43^{k}$

(iii) uplift on dam base: $3.7 \times 62.4 \times \frac{6.2}{2} = 0.72^{k}$

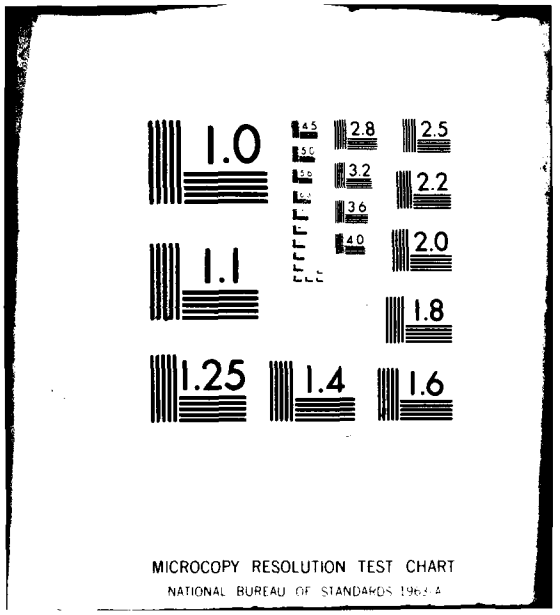
(iv) ice $= 5^{k}$

FS (friction-shear method) $= \frac{(0.65)(3.56 - 0.72) + (.05 \times 144 \times 6.2)}{5 + 0.43}$

$$= \frac{1.85^{k} + 44.6^{k}}{5.43^{k}} = 8.5 \pm \quad \text{-ok-}$$

AD-A086 356 NEW YORK STATE DEPT OF ENVIRONMENTAL CONSERVATION ALBANY F/G 13/13
NATIONAL DAM SAFETY PROGRAM. ALPINA DAM (INVENTORY NUMBER NY 77--FTC(U)
FEB 80 J B STETSON DACW51-79-C-0001

UNCLASSIFIED NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

APPENDIX E

REFERENCES

APPENDIX

REFERENCES

1. Department of the Army, Office of the Chief of Engineers. National Program of Investigation of Dams; Appendix D: Recommended Guidelines for Safety Inspection of Dams, 1976

2. U.S. Nuclear Regulatory Commission: Design Basis Floods for Nuclear Power Plants, Regulating Guide 1.59, Revision 2, August 1977

3. Linsley and Franzini: Water Resources Engineering, Second Edition, McGraw-Hill (1972)

4. W. Viessman, Jr., J. Knapp, G. Lewis, 1977, 2nd Edition, Introduction to Hydrology

5. Ven Te Chow: Handbook of Applied Hydrology, McGraw-Hill, 1964

6. The Hydrologic Engineering Center: Computer Program 723-X6-L2010, HEC-1 Flood Hydrograph Package, User's Manual, Corps of Engineers, U.S. Army, 609 Second Street, Davis, California 95616, January 1973

7. The Hydrologic Engineering Center, Computer Program: Flood Hydrograph Package (HEC-1) Users Manual For Dam Safety

8. Soil Conservation Service (Engineering Division): Urban Hydrology for Small Watersheds, Technical Release No. 55, U.S. Department of Agriculture, January 1975

9. H.W. King, E.F. Brater: Handbook of Hydraulics, McGraw-Hill, 5th Edition, 1963

10. Ven Te Chow: Open Channel Hydraulics, McGraw-Hill, 1959

11. Bureau of Reclamation, United States Department of the Interior, Design of Small Dams: A Water Resources Technical Publication, Third Printing, 1965

12. J.T. Riedel, J.F. Appleby and R.W. Schloemer: Hydrometeorological Report No. 33, U.S. Department of Commerce, U.S. Department of Army, Corps of Engineers, Washington, D.C., April 1956. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

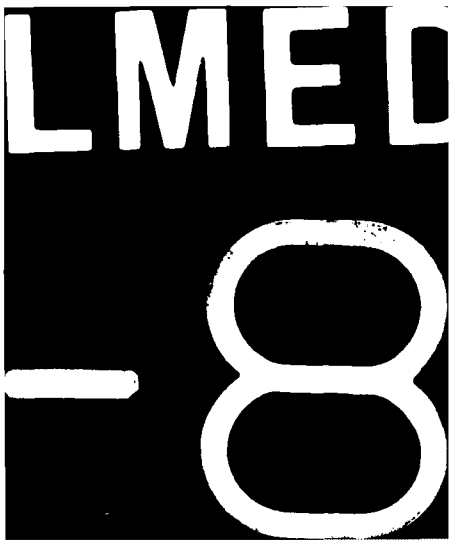
13. "Permeability Pore Pressure, and Uplift in Gravity Dams", by Roy W. Carlson, Transactions ASCE, Volume 122, 1957

14. The University of the State of New York - The State Education Department - State Museum and Science Service - Geological Survey: Geological Map of New York (1961)

15. Y.W. Isachsen and W.G. McKendree, 1977, Preliminary Brittle Structures Map of New York, Adirondack Sheet: New York State Museum Map and Chart Series No. 31A

16. Eastern New York River Basins, Black and St. Lawrence River Basins, 1970: United States Department of Agriculture, Appendix A

17. C.H. Smythe and A.F. Buddington, 1926, Geology of the Lake Bonaparte Quadrangle: New York State Museum Bull. 269, Page 106


LMED
8